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ELEMENTS OF CHEMISTRY

AND

DENTAL MATERIA MEDICA

BY

J. S. CASSIDY, D.D.S., M.D

PROFESSOR OF CHEMISTRY AND MATERIA MEDICA IN OHIO COLLEGE OF
DENTAL SURGERY



CINCINNATI

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BY JAMES S. CASSIDY.

TO
ELIZA GUYTON,
IN LOVING APPRECIATION OF HER
CHRISTIAN FORTITUDE
AND
EXCEEDING PATIENCE
UNDER MANY TRYING CIRCUMSTANCES,

This Book is Affectionately Inscribed,

BY HER HUSBAND,

THE AUTHOR.

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NEW YORK

WILLIAM
JAMES
COTTON

PREFACE.

The labor involved in the preparation of the following pages, was assumed at the solicitation of members of my classes; and also for the purpose of testing the comparative value, to Dental Students, of the two approved didactic methods of teaching Chemistry and Materia Medica, *i. e.*, by Lectures and quiz, and by Recitation from approved Text-books, in connection with suggestive experiments.

The author lays no claim to originality of style, or system, in presenting the subjects. The subjects themselves, with few exceptions, are not elastic, and admit of only slight variations from the usual accepted phraseology.

Division of the volume into Three Parts was made, with a view to the convenience of the three graded classes, which now obtain, as required by the Association of Dental Faculties.

The space given to the consideration of Chemical Philosophy, and Compound Radicals, as well as that occupied by the few simple rules to be observed in Prescription writing, and the approximate re-

lations between the Metric, and Apothecaries systems, of weights and measures, will not, I trust, be regarded as superfluous; for dental students, as well as those of medicine, are often sadly deficient in a clear knowledge of those important accomplishments.

It may appear on first sight, that our *Materia Medica* is too limited, and overshadowed by the governing science of Chemistry; but the combination of these two branches of our curriculum, as herein presented—which I believe is unique, and to the advantage of the student—necessarily prevents the complete exposition of at least those drugs which are unessential in dental practice.

Description of the work performed by the class, in our Chemical Laboratory, on Qualitative Analysis, has been omitted, inasmuch as a monograph on that subject, will probably soon be forthcoming.

I have, of necessity, borrowed freely from the authorities consulted, to all of whom it would be impossible to give individual credit. Of these, however, we must not forget the collective credit due to various dental, medical, and scientific journals, and in especial manner to Fowne's, Atfield's, Clark's, Appleton's, Mitchell's Dental, Roscoe's, Crooke's, and Barker's Chemistry; Miller's Microbes, and Biddle's, Potter's, Gorgas' Dental, Bar-

tholow's, Farquharson's, and Waring's *Materia Medica*. To them, and many other friends, who have assisted to render my task a labor of love, I hereby extend my grateful acknowledgments.

J. S. CASSIDY,

1555 Madison Avenue, Covington, Ky., *December 15, 1892.*

NOTE.—By kindly referring to the Index, the reader will observe a slight departure from the usual orthography of certain words. Thus will be found *Chlorin*, *Iodin*, *Glycerin*, *Cocain*, *Oxid*, *Sulfur*, etc.

This innovation is in accord with the recent official report of a Committee of the Chemical Section of the American Association for the Advancement of Science, and will probably be generally adopted in the very near future. J. S. C.

THE
SCHOOL
OF
THE
FUTURE

INORGANIC CHEMISTRY.

PART FIRST.

CHAPTER I.

PHYSICS.

Matter and Force are involved in the consideration of all natural phenomena.

MATTER, SUBSTANCE, of which the physical universe is composed.

FORCE, modes of motion by which are manifested heat, light, magnetism, and electricity; also motor, or mechanical motion. All of these are inter-convertible.

SPECIFIC GRAVITY. Special kinds of matter, as water, chloroform, gold, etc., differ from each other in weight; or equal bulks of them are not affected equally by the attraction of gravitation. They differ therefore in specific gravity, or in the force with which they fall to the earth.

The specific gravity of any substance is its weight compared with the weight of an equal bulk of the standard substance reckoned as unity.

In the case of all solids and liquids, distilled water at a temperature of 4°C. (39°F.), is the stand-

ard of unity. A given temperature is necessary, inasmuch as change, in this respect, either increases or decreases the volume. The specific gravity of any liquid is ascertained by dividing its weight, at the standard temperature, by the weight of an equal bulk of water. The quotient will be greater or less than unity, according as the weight of the liquid in question, is greater or less than that of the standard.

The specific gravity of a solid is obtained by the same rule, viz., divide the weight of the solid by the weight of the same bulk of the standard (water). If the solid be heavier than water, it is first weighed in air, then in water; it thus weighs less in water than in air, and the *loss* in weight expresses the weight of its own *bulk* of the liquid. Its weight in air is divided by the amount it loses by immersion in water; the quotient will be the specific gravity of the solid.

When the solid body is soluble in water, then some non-solvent liquid, the specific gravity of which is known, is taken as a substitute.

In determining the specific gravity of a solid *lighter* than water, various methods are employed. A piece of metal, for instance, may be attached to overcome the buoyancy of the light body, and mathematical results thus obtained.

A sufficiently exact key to the general doctrine of the equilibrium of floating bodies is afforded by the theorem of Archimedes.

A solid of less specific gravity than the liquid in which it is placed will float. It displaces, at the same time, a quantity of liquid exactly equal to its own weight. Thus, a solid possessing one-half the specific gravity of water, if placed in that liquid, will sink one-half its bulk, the weight of the water displaced, being equal to the weight in air of the floating body.

It is on this principle that instruments known as hydrometers, urinometers, etc., are constructed, by which a graduated stem, made of glass or metal, floats in the liquid to be tested. If the liquid be heavier than unity, the stem will be raised accordingly, and *vice versa*, with liquids lighter than water. The specific gravity of the liquid will be indicated by the coincidence of its surface with the figures on the graduated scale.

The specific weights of gases are obtained by dividing their weight by an equal volume of air. In many cases hydrogen is taken as the standard of unity for gases. The term *density*, when applied to a gas, implies that hydrogen is reckoned as unity, and when the term specific gravity is em-

ployed with reference to the same, or some other gas, it is understood that *air* is the standard of unity.

PROPERTIES OF GASES.

Gases or vapors, whether simple or compound, are obviously affected by the attraction of gravitation, in common with other forms of matter. .

The atmosphere is the familiar prototype of gases in general, and serves to exhibit certain phenomena pertaining to all of them; one of which is the property of *elasticity*.

Air contained in a cylinder, in which works an air-tight piston suffers condensation, if the piston be pressed down; whereas, if the pressure be lessened by raising the piston, the air will expand and completely fill the enlarged space in the cylinder.

The volume of a given weight of gas depends on the pressure: the relation being expressed by the law of Mariotte, "The volume of a gas is inversely as the pressure; the density and elastic force are directly as the pressure and inversely as the volume." Thus, 100 cubic inches of gas at the ordinary pressure, will expand to 200 cubic inches, if the pressure be reduced one-half, and shrink to a volume of 50 cubic inches if the pressure be doubled.

The atmosphere is the ocean of gaseous matter surrounding the earth and held to the latter by the

attraction of gravitation. Its weight, or density, is therefore greater at the sea level, than at high elevations; the density decreasing uniformly as we ascend.

Instruments to indicate changes in the weight, or pressure of the atmosphere at different elevations, or temporary changes in the pressure at a given elevation, are called barometers.

The mercurial barometer is constructed by filling completely, a glass tube about 35 inches long with clean, dry mercury, and the open end of the tube inverted in a reservoir of mercury. It will then be seen that the mercurial column will descend in the tube—leaving an empty space above—until it reaches a position about 30 inches above the surface of the mercury in the reservoir, at which point it remains balanced by the pressure of the atmosphere. Now, if such a column of mercury, having an area of 1 inch, be weighed, it will be found to weigh between 14 and 15 lbs., proving that the pressure of the atmosphere is nearly 15 lbs. on every inch of the earth's surface.

The diffusive power of gases, depends on their relative densities; the rule being that “the diffusive power of a gas is inversely as the square root of its density.” If a vessel be divided in two equal compartments by a thin, dry partition of plaster of

paris, and the two compartments filled with different gases, incapable of acting chemically on each other at ordinary temperatures, it will be found that diffusion into each other will take place according to the above rule.

If one compartment be filled with H, and the other with O, 4 cubic inches of H will pass through the porous plaster of paris diaphragm, to the oxygen side, while 1 cubic inch of O will pass to the H side. The densities of these two gases are as 1 to 16; their relative rates of diffusion, are inversely as the square roots of these numbers, or as 4 to 1.

The inherent diffusive power of gases, whereby the atmosphere absorbs them, prevents the accumulation of poisonous vapors in confined localities, their wide dissemination permitting the atmospheric ozone to destroy them easily; or they become so attenuated in the air, as is the case with carbon-dioxide, ammonia, etc., that they exert no appreciable influence on the health of the animal kingdom. Certain gases, though comparatively dense, diffuse most readily through *wet* membranes on account of their great solubility; as in the process of animal respiration, the CO_2 , which is freely soluble in water, escapes easily thus dissolved, through the wet membranes of the lungs.

CHAPTER II.

EFFECTS OF HEAT.

One of the most general effects produced on matter, by increasing temperature, is *expansion*. If a metallic bar be fitted accurately to a guage when cold, and then slightly heated, it will be found too long to enter the gauge. This is due to the heat overcoming to that extent the attraction of cohesion existing between the molecules of the bar. If the heat be continued, the molecules may be driven so far apart, that the metal will assume the liquid state; and, finally, the metal may be made to volatilize, or become gaseous, in which condition, the molecules are *widely* separated. By abstracting the heat, or allowing the mass to cool, *contraction* takes place; the space between the molecules is lessened, the metallic vapor changes again to a liquid, and this back to the original solid condition. The expansibility of most solids varies with the increment of heat, zinc, lead, silver, copper, gold, soft iron, tempered steel, untempered steel, common white glass, platinum and flint glass, expand in the order named.

It is seen that glass and platinum expand and contract, nearly alike, and porcelain, whose nature and expansive power approximates the former material, permits fusion with platinum in the manufacture of artificial teeth, Logan crowns, etc., without the danger of fracture, by excessive changes in temperature.

Liquids not only differ in dilation by equal amounts of heat, but they differ greatly in their *rate* of expansion, by increasing temperature.

Mercury expands more uniformly between 0°C , and 100°C , than other liquids, and for this reason it is employed in the construction of thermometers, instruments for measuring changes in temperature. A glass tube closed at one end and blown to a bulb, the other end left open and drawn to a point, is partially filled with mercury. The bulb is carefully heated, by which the air is driven out, the tube being completely filled with the expanded mercury; the open end is then hermetically sealed, and on cooling, the mercury contracts, leaving an empty space above. The height of the mercurial column is marked on the glass, at two fixed points. These two points are found at the boiling temperature of water, the barometric pressure being noted, and at the freezing of water, which is constant. Between these two marks, the

tube is divided into an arbitrary number of degrees, the scale continuing above and below each mark respectively, to indicate temperatures above and below the boiling and freezing points of water. The Raumer scale is divided into 80 degrees; the boiling point at 80° , the freezing point at 0° . Fahrenheit's scale contains 180 degrees, but he placed his 0° , 32 degrees below the freezing point; consequently the boiling point is expressed by Fahrenheit at 212° . According to the centegrade thermometer, the freezing of water is indicated by 0° , and the boiling point by 100° . The graduation of the latter instrument is considered the most rational. It is adopted by nearly all scientific bodies. Fresh water when subjected to the freezing process continues to contract in volume until it reaches a temperature of 4°C , (39°F)—its point of maximum density. On further cooling it expands, until the freezing temperature is reached, 0°C , (32°F .) In the immediate act of solidifying, great enlargement takes place: ice is therefore formed on the surface, being lighter than the liquid water beneath. On melting, the reverse takes place; the volume contracting until the temperature of 4°C is reached, after which expansion proceeds with increasing heat. In regard to the expansion of gases by heat, the following statement will suffice:

I. All gases or vapors when remote from their condensing points, expand nearly alike for equal increments of heat.

II. The *rate* of expansion is uniform for all degrees of heat.

III. The *rate* of expansion is not altered by a change in the state of compression or elastic force of the gas itself.

IV. The actual amount of expansion is equal to $\frac{11}{3000}$ of the volume of the gas at 0°C, for each degree of that scale: 3,000 volumes of gas at 0°C become 3,011 at 1°C, 3,022 volumes at 2°C, etc.

CONDUCTION OF HEAT.

The power of conducting heat varies greatly with different bodies. If rods of the same size of different solids have each one extremity heated equally, the other extremities will become heated in the ratio of the conducting power of the material.

The metals as a class are the best conductors of heat (and electricity), silver being first. Rating the conducting power for silver at 1,000 that of

Copper is736

Gold is.532

Tin is.....145

Iron is119

Lead is.....	85
Platinum is.....	84
Normal Moist Dentine is.....	15

Gold, and mercurial alloys of copper, and of silver and tin—known as amalgams—are much better conductors of heat than tooth structure, and to that extent, at least, are objectionable materials for filling cavities in teeth. In sudden thermal changes in the mouth, heat is conducted by them so rapidly to or from the dental pulp, as to endanger the comfort and life of that organ.

Various other solids, mainly non-metallic, such as glass, wood, vulcanite, gutta-percha, zinc oxide cements, etc., are *poor* conductors. The last two substances are frequently employed singly and sometimes in union, as a protecting covering to the pulp, before applying the metallic filling.

Liquids and gases are classed as *non-conductors* of heat; their increase in temperature is due to convection, or the circulation of their particles within the mass. Those particles nearest to the source of artificial heat move away, giving place to others of lower temperature, until all the particles acted upon are involved in the heating process.

CHAPTER III.

SPECIFIC HEAT.

Equal weights of different substances require different amounts of heat to raise them a given temperature. If 1 lb. of water at $40^{\circ}\text{C}.$, and 1 lb. of water at $10^{\circ}\text{C}.$, be mixed, the mixture will possess the mean temperature of both, or $25^{\circ}\text{C}.$ If 1 lb. of mercury at $40^{\circ}\text{C}.$ be mixed with 1 lb. of mercury at $10^{\circ}\text{C}.$, the mixture will also possess a temperature the mean of 40 and 10, or $25^{\circ}\text{C}.$ Now, if 1 lb. of water, at $40^{\circ}\text{C}.$, be mixed with 1 lb. of mercury at $10^{\circ}\text{C}.$, the temperature will *not* be $25^{\circ}\text{C}.$, but will be $39^{\circ}\text{C}.$ The lb. of water at $40^{\circ}\text{C}.$ loses but 1° in cooling from 40° to 39° , while it raises its own weight of mercury 29° , from 10° to 39° ; the specific heat, *i. e.*, calorific capacity of water is, therefore, 29 times greater than mercury. The amount of heat sufficient to raise a given weight of water through a given range of temperature, referred relatively to the amount of heat required to raise equal weights of the different substances through the same range of temperature, implies the specific heats—capacities for heat—of the various

substances. The specific heat of water is greater than that of any other substance, excepting hydrogen. Taking water as unity—1,000—the capacity for heat, of an equal weight of hydrogen, is expressed by 3.490, and gold by 0.324.

But if, instead of equal weights, quantities proportional to the atomic weights of elements be taken, there will be found a remarkable relation, viz: "The atomic weights of the various elements are inversely proportional to the specific heats, so that the product of the specific heats into the atomic weights is approximately a constant number. The same quantity of heat will produce a given change of temperature in 7 grains of Li., 56 of Fe, 108 of Ag, 197 of Au, etc. These numbers represent the atomic weights of the elements named. In other words, the *atoms* of the several elements have equal capacities for heat.

LATENT HEAT.—Whenever a solid *melts* or *fuses*, a certain amount of sensible heat disappears and remains latent in the liquid.

One lb. of powdered ice or snow, at $0^{\circ}\text{C}.$, placed in 1 lb. of water at $70^{\circ}\text{C}.$ will melt; the temperature, however, will not be $35^{\circ}\text{C}.$ —the mean of 70° and 0° —but will be reduced to $0^{\circ}\text{C}.$ by the melting of the ice, showing that $70^{\circ}\text{C}.$ of heat have been

absorbed in the change of state from solid to liquid.

$$\left\{ \begin{array}{l} 1 \text{ lb. of water at } 70^{\circ}\text{C.} \\ 1 \text{ lb. of ice at } 0^{\circ}\text{C.} \end{array} \right\} = 70^{\circ}\text{C.}$$

This heat of fluidity is set free, when the water again freezes; for, although the temperature of the surrounding medium may be much lower than the freezing point of water, so much latent heat is set free by the change of state from liquid to solid, as to keep the temperature up to 0°C.

This law of sensible heat becoming latent, whenever any solid becomes a liquid, also applies to solids and liquids becoming gases, a certain amount of heat disappears and remains latent in the gas; and heat, to an exactly corresponding amount is set free, when the gas again assumes the liquid state.

A pound of water at 100°C. mixed with a pound of water at 0°C. , will occasion a temperature in the mixture of 50°C. , but a pound of *steam* at 100°C. , if condensed to a liquid in water at 0°C. , will, by giving up its latent heat, confer a temperature equal to its own of 100°C. on 5.4 pounds of water at 0°C. It follows, that temperature is lessened by change of state from solid to liquid, and from liquid to vapor. Fahrenheit mixed powdered ice and salt: the mixture became liquid and re-

duced the temperature 32°F. (by his scale) below the freezing point of water. He supposed this to be the greatest absence of heat that could be artificially produced, and named the point *zero* (0°F.)

Ordinary chemical action always occasions a rise in temperature; but mere *solutions* generally lower the temperature because of the amount of heat absorbed overcoming the heat developed by weak chemical affinities. This is the principle of frigorific mixtures, such as powdered calcium chloride and snow; ammonium nitrate and water, etc.

The great reduction of temperature occasioned by the rapid evaporation of highly volatile liquids, such as ethyl chloride, ethyl oxide, etc., is due to the heat absorbed and which remains latent in the escaping vapor. In minor surgical operations, some of these highly volatile liquids are applied to the part, in the form of a spray, to obtund sensibility.

Water evaporates at all temperatures, and, as with other liquids, its evaporation is increased by increase of heat. When the boiling point is reached there is visible formation in the body of the liquid of bubbles of gas, which ascend to the surface and escape into the atmosphere as vapor, carrying the latent heat with them, thus preventing the liquid from assuming a higher tempera-

ture. Water (or other liquid) boils, when the elasticity of its vapor is able to overcome the pressure upon it.

At the sea level water boils at 100°C. , (212°F.), but, at higher elevations, as on mountain tops, ebullition takes place at a lower temperature, because of the lessened pressure, or weight of the atmosphere. If water be made to boil in a partially filled flask, the vessel then tightly corked and removed from the source of heat, the boiling of the water will soon cease by the pressure of its own inclosed vapor. By applying to the surface of the vessel a wet sponge, which condenses the vapor and thus diminishes the pressure, ebullition again takes place; and this repeatedly, until the water in the flask is reduced to a common temperature.

CHAPTER IV.

DISTILLATION.

The object of distillation is either to separate different substances which rise in vapor, at different temperatures, from a composite liquid, or to part volatile liquids from substances that do not volatilize. When the process applies to solid bodies passing directly to the gaseous state and back again to the solid form, it is called *sublimation*.

Liquids evaporate at temperatures below the boiling points, and the vapors thus escaping, as in the case of water from the ocean and from the general surface of the earth, are virtually distilled.

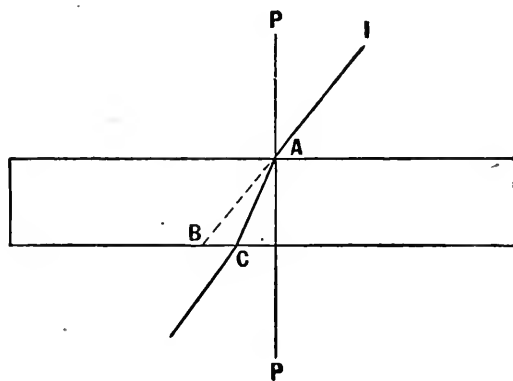
Vapor of water exists in the atmosphere at all times and in all situations. If the aqueous vapor be in condition of greatest possible density for the temperature, or as is often but incorrectly expressed, the air be saturated with vapor of water, the slightest reduction of temperature will cause the deposition of a portion in the liquid form. If, however, the vapor of water be below the point of maximum density, that is, in an expanded condition, which is generally the case, a considerable

fall of temperature may occur before the dew-point, or liquefaction commences. The resemblance between vapors, and what are ordinarily known as gases suggested means by which all of the latter class have been converted into liquids, by the influence of cold combined with pressure. Thus, chlorine gas at a pressure of 4 atmospheres and a temperature of 15.5°C ., and nitrous oxide gas at a pressure of 50 atmospheres and a temperature of 7.2°C ., are condensed to the liquid state.

NATURE OF HEAT.—Although the sources of heat are numerous, such as the sun itself, the interior of the earth, mechanical motion (the latter including percussion, friction and condensation), electric excitation and chemical action, a rise in temperature is caused in all cases by increased motions induced in the particles of matter involved in its development. It is probable that absolute zero or perfect absence of molecular motion, does not exist. That matter changing from the gaseous to the liquid, and on to the solid state, is owing to a lessening in the molecular and atomic motion, consequent on the withdrawal of a corresponding equivalent of heat, and *vice versa*.

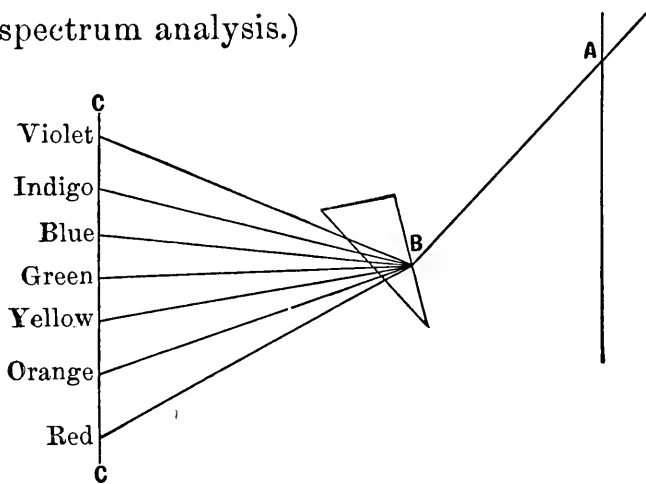
LIGHT.—Rays of light, the effect of undulating motion, projected from a luminous body, either celestial or terrestrial, while passing through homo-

geneous diaphanous media, travel in straight lines, and with great velocity. If, however, the media through which the light passes, should vary in density, the ray of light will be changed in direction, will be bent from a continuous straight line; in short, *refracted*. The rule of simple refraction of light is stated thus: *when a ray of light passes from a rare through a denser medium it is bent toward a line drawn perpendicular to the surface of the latter, and when passing from a dense to a rarer medium it is bent from the perpendicular line, and takes a direction parallel with a continuation of its former course, provided the medium be the same before and after refraction.*



If the incident ray of light, *I*, fall upon the plate glass, *A*, at the angle shown, then instead of passing straight through the glass to *B*, it will be bent toward the perpendicular line *P* to *C*, and on

emerging again into the air at *C*, it will be bent *from* the perpendicular line, assuming a direction parallel to its former course. It is upon this principle that prisms and lenses depend. Convex surfaces converging the refracted rays, and concave separating them more widely. In case the refracting substances should be prismatic in form instead of possessing parallel sides like plate glass, the ray of light will be refracted as described, and also decomposed into colors of different refrangibility. (See spectrum analysis.)

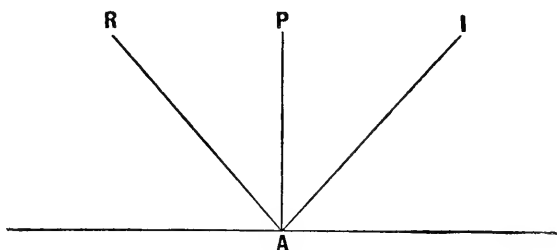


If a ray of sunlight *A* be admitted into a dark room and allowed to pass through a glass prism at *B*, the light is refracted; and if thrown on a white screen *C*, it will be seen to consist of several colors, which form what is known as the solar spectrum, and also as the *primary colors*. These colors and their various shades are dependent on

mathematical perception. The red color is distinguished as such, because the vibrations of light, producing it are received by the retina of the eye, at the rate, in round numbers, of about 450 million million times a second, and the violet at about 785 million million times a second. The intermediate colors and the infinite number of tints accompanying them are due to the variations in the number of vibrations received by the normal human retina. Hence, color-blindness is owing to the inability of the retina to receive a given number of vibrations within a given time. The solar spectrum is often divided into three different parts; the most refrangible colors are known as the blue rays, the richest in *chemical influence*; the least refrangible, or red, the *heat* rays, and the intermediate colors, the *light* rays. An invisible ray, more refrangible than the violet, is richer in actinic power than the latter, and a ray, also invisible, less refrangible than any, possesses greater heating power than the red.

REFLECTION OF LIGHT.—When a ray of light falls upon surfaces, it is either absorbed and thus it more or less disappears; or, it suffers reflection and thus assumes a new direction. The law of the reflection of light is simply stated.

When a ray of light, *I*, falls upon a polished surface, *A*, at a certain angle, it is reflected in the direction of *R*, which makes an angle with the perpendicular line, *P*, equal to the angle of incidence. In other words, the angles of incidence and reflection are equal.



Almost all things upon the general surface of the earth, incline toward each other at promiscuous angles, and so reflect the light *diffused*. It is by means of this diffused reflected light that we are enabled to perceive objects distinctly. The color of an object is due to its ability to reflect the special rays or combination of them, by which it is distinguished. A white object reflects all the rays of light that fall upon it, while black absorbs all, and reflects none.

RADIANT HEAT.—A few salient features of radiant heat may be properly considered as an accompaniment to our studies of the nature of light.

When a hot body has its source of heat withdrawn, it begins to cool immediately. It loses heat in three ways.

1st. By conduction; by means of the support upon which it rests.

2nd. By convection; the particles of air surrounding the heated body, move away, carrying their modicum of heat with them, and giving place to other, colder, particles of air, which also become heated and move away, and so on, all in accordance with the law of hydrostatics.

3rd. By radiation; a portion of heat escapes by vibration in all directions from the heated body. It meets with no interference from the air, and suffers absorption and reflection, by surrounding bodies, like rays of light.

In fact, radiant heat resembles light in many respects; it travels with great velocity; it is reflected from surfaces; it enters and traverses certain media, undergoing at the same time refraction, absorption, and polarization, obeying in these respects the same laws which regulate the corresponding phenomena of light. Polished concave surfaces will therefore reflect and concentrate the heat rays to a focus, while convex surfaces will cause them to diverge. Smooth, bright surfaces reflect nearly all the heat that falls upon them, and thus remain cool; dark, rough surfaces, on the contrary, soon become heated, by absorbing the radiant heat, and reflecting scarcely any. Good re-

flectors are poor absorbers of heat, and *vice versa*. The power of absorbing and of radiating heat, is in direct proportion. The surface which absorbs heat most perfectly, will when heated, also radiate most perfectly. If two vessels of equal size and material, one having a polished white surface, the other a dark, rough surface, be filled with hot water, the rate of cooling by radiation will be unequal; the water in the latter vessel will lose its heat more rapidly than that in the one with the polished surface. Hence, the dental pulp when protected by a highly polished filling is not so much affected by thermal changes, as it would be in case the surface of the filling is roughly finished. On *this principle* also, investments of artificial teeth should be smoothly finished in order to prevent undue radiation of heat from the surface during the process of soldering. At the same time, much heat will be economized, if the blow-pipe flame be thrown in such direction as to compel the reflected heat to strike only some part of the investment.

CHAPTER V.

CONSTITUTION OF MATTER.

All kinds of matter may be divided into *single* or *elementary* and *compound* forms. A compound consists of two or more elements united together in certain proportions. An acquaintance therefore with the names of the several elements symbolized by certain letters, and their atomic weights, or proportions in which they unite to form compounds, is necessary to the beginning of chemical studies. The following table is presented for this purpose :

CONSTITUTION OF MATTER.

NAME.	SYMBOL.	ATOMIC WEIGHT.
Aluminum.....	Al.....	27
Arsenic.....	As.....	75
Antimony.....	Sb. (Stibium) ..	120
Boron.....	B.....	11
Bromine.....	Br.....	80
Barium.....	Ba.....	137
Bismuth.....	Bi.....	208
Carbon.....	C.....	12
Chlorine.....	Cl.....	35-5
Calcium.....	Ca.....	40

NAME.	SYMBOL.	ATOMIC WEIGHT.
Chromium.....	Cr.....	52
Cobalt.....	Co.....	59
Copper	Cu. (Cuprum)	63-8
Columbium	Cb.....	94
Cadmium.....	Cd.....	112
Caesium	Cs.....	133
Cerium.....	Ce.....	141
Didymium	Di.....	142-3
Decipium.....	Dp.....	
Erbium.....	Er.....	166
Flourine.....	F.....	19
Glucinum.....	Gl.....	9
Gallium	Ga.....	69
Gold.....	Au. (Aurum).....	196-5
<i>Hydrogen</i>	H.....	1
Iron.....	Fe. (Ferrum).....	56
Indium.....	In.....	113-6
<i>Iodine</i>	I.....	127
Iridium.....	Ir.....	193
Lithium.....	Li.....	7
Lanthanum.....	La.....	138-2
Lead.....	Pb. (Plumbum).....	207
Magnesium.....	Mg.....	24
Manganese	Mn.....	55
Molybdenum.....	Mo.....	96
<i>Mercury</i>	Hg. (Hydrargyrum).....	200
<i>Nitrogen</i>	N.....	14

NAME.	SYMBOL.	ATOMIC WEIGHT.
Nickel.....	Ni.....	58
<i>Oxygen</i>	O.....	16
Osmium.....	Os	198
<i>Phosphorus</i>	P.....	31
Potassium.....	K. (Kalium)..	39
Platinum	Pt	195
Rubidium.....	Rb.....	85-5
Ruthenium	Ru.....	104
Rhodium.....	Rh.....	104
Sodium.....	Na. (Natrium).....	23
<i>Silicon</i>	Si.....	28
<i>Sulphur</i>	S.....	32
Scandium.....	Sc.....	44
<i>Selenium</i>	Se.....	79
Strontium.....	Sr.....	87-5
Silver.....	Ag. (Argentum)	108
Titanium	Ti.....	48
Tin.....	Sn. (Stannum).....	118
<i>Tellurium</i>	Te.....	126
Terbium.....	Tb	
Tantalum.....	Ta.....	182-6
Tungsten.....	W. (Wolfram).....	184
Thulium.....	Tm.....	
Thallium	Tl.....	204
Thorium.....	Th.....	232
Uranium.....	U.....	239
Vanadium.....	V.....	51-5

NAME.	SYMBOL.	ATOMIC WEIGHT.
Yttrium	Yt.....	89
Ytterbium	Yb.....	173
Zinc.....	Zn.....	65
Zirconium.....	Zr.....	90

For convenience of description, matter is divided into three physical conditions; namely, *Solids*, *Liquids* and *Gases*.

Gold and marble are examples of solids; ordinary water and the oils, of liquids; and the atmosphere and nitrous oxide, of gases.

Each of these physical conditions is sub-divided into *masses*, *molecules* and *atoms*.

A *mass* of matter is any quantity of matter appreciable to the senses. A *molecule* is the smallest particle of matter that can exist without losing its identity. An *atom* is the still smaller particle of matter obtained by division of a molecule. The earth and a grain of sand are equally *masses* of matter. The molecules of marble, consisting of the metal calcium, and the non-metal carbon, and the gas oxygen; and the molecule of nitrous oxide, composed of the two gasses, nitrogen and oxygen, may be split up by chemical means into their constituent *atoms*. From the molecule of marble the individual atoms of calcium, carbon, and oxygen;

and from the molecule of nitrous oxide, nitrogen and oxygen can be obtained.

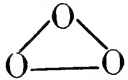
The *atoms* of calcium, carbon, and oxygen, in marble; and of nitrogen, and oxygen, in nitrous oxide, can not be further separated into simpler forms. An atom itself is indivisible.

Chemical action involves the play of selective affinities at given temperatures, between the constituent atoms only, of the acting substances.

The force of *attraction* exerted on the above three divisions of matter is threefold.

The attraction of *gravitation* between *masses* of matter. The earth and other planets are held to the sun, and the grain of sand to the earth, by the attraction of gravitation. The attraction between homogeneous *molecules*, as those of marble, gold, etc., is called *cohesion*, while that which holds the *atoms* together to form the molecule is called *chemism*, chemical attraction or chemical affinity. The latter form of attraction is considered as closely allied to the electric condition. As a class, the atoms of the non-metallic elements, as oxygen, sulphur, iodine, etc., are electro-negative, those of the metallic elements, like silver, calcium and potassium, are electro-positive. These two classes are strongly attractive toward each other, while the atoms of those elements intermediate between

the non-metallic and metallic elements, such as arsenic, antimony, etc., will combine readily with the atoms of either the negative or positive kind.

A molecule may be defined as consisting of a definite number of atoms. A *simple* molecule being made up of atoms of the same kind, as, for example, a molecule of hydrogen, $\text{H}-\text{H}$; or of oxygen, $\text{O}=\text{O}$; or of ozone,  A *compound*

molecule contains two or more atoms of different kinds, as water H_2O , or marble CaCO_3 . These facts are ascertained by analysis and synthesis.

Analysis, which separates the constituent elements in compounds, and *synthesis*, which recombines the elements to form compounds. From a mass of *simple* molecules only simple matter comes, but from a mass of compound molecules, simple matter is obtained.

From a mass of gold nothing but gold can be obtained. Gold is, therefore, a simple form of matter, or is an element. Water H_2O , on the contrary, is a compound, because by analysis it gives up two different substances, hydrogen and oxygen; but all efforts to divide either hydrogen or oxygen into simpler forms fail; they still remain hydrogen and oxygen. They are, therefore, each elementary.

CHAPTER VI.

CHEMICAL NOTATION AND NOMENCLATURE.

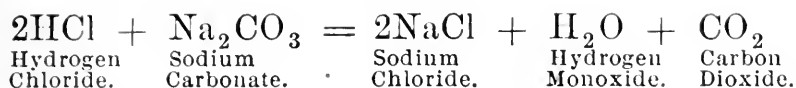
The letters, symbols—H, O, or N, etc., in the table, on p. 26, 27, not only indicate the presence of hydrogen, oxygen, nitrogen, etc., respectively, but also certain quantities by weight of each, proportional to their atomic weight.

Thus, the letter H symbolizes hydrogen, and at the same time indicates 1 part by weight of hydrogen. Hydrogen being the lightest substance known, the weight of its atom is taken as unity. The letter O, one atom, or 16 parts by weight of oxygen. The letter N, one atom, or 14 parts by weight of nitrogen, etc.

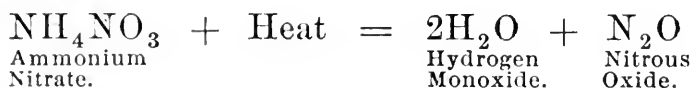
Combination between elements to form compound molecules—which latter suggest a proportional weight of a mass of the given compound—is represented by placing the symbols in immediate juxtaposition. Thus, HCl is a compound-molecule—consisting of one atom, or 1 part by weight of hydrogen, united to one atom, or 35—5 parts by weight of chlorine. When there are more than one atom of a certain element forming the mole-

cule, the appropriate figure is placed to the right and a little below the symbol. The molecule of water contains two atoms of hydrogen and one of oxygen; the formula for water is, therefore, H_2O . The formula of peroxide of hydrogen, which contains two atoms of hydrogen and *two* atoms of oxygen is written H_2O_2 . When it is necessary to multiply the molecule itself, the figure is placed to the left, and on a line with the first symbol. The formula $2\text{H}_2\text{O}$, means two molecules of water. Sometimes when the molecule is somewhat complicated, it is inclosed in brackets, and if multiplied, the figure is placed either to the left and on a line, or to the right and a little below. Thus, $3(\text{NH}_4\text{Cl})$ or $(\text{NH}_4\text{Cl})_3$ represents three molecules of a certain compound, each molecule containing 4 atoms of hydrogen, 1 atom of nitrogen, and 1 atom of chlorine. These few examples will suffice for similar explanation of all other formulæ.

In chemical changes every atom of each element involved, must be accounted for. This is done by placing the formulæ of the reacting bodies first, with a plus mark between them, followed by a sign of equality and then the formulæ of the bodies produced by the change, with a plus mark between them. All of which constitutes a chemical equation:



The above equation is also an illustration of what is termed double decomposition and recombination. Two molecules of hydrogen chloride, and one molecule of sodium carbonate react upon each other by means of the mutual affinities between their atoms. The 2 atoms of hydrogen take one atom from the 3 atoms of oxygen, forming a molecule of water, (H₂O.) The 2 atoms of chlorine set free, unite with the 2 atoms of Na forming 2 molecules of common salt, (2 NaCl,) and the remaining group, CO₂ escapes as a molecule of carbonic acid gas. Heat alone is oftentimes a most important factor in causing chemical decomposition and recombination. If a salt known as ammonium nitrate be placed in a flask and heated sufficiently, an interchange of the atoms of the constituent elements will take place, according to the following equation:



It will be noticed by referring to the compounds in the preceding equations, that their *names* suggest their composition. When a compound molecule is composed of only two *elements* its chemical name always ends in *ide*, as, hydrogen *chloride*,

meaning, evidently, a combination of H and Cl, (HCl;) hydrogen monoxide, of H and O, (H_2O ;) sodium chloride, of Na and Cl, (NaCl ;) nitrous oxide, of N and O, (N_2O .) The most highly electro-positive element in the formulæ (a question to be studied later), is generally placed first, a rule, however, sometimes departed from, in order to better explain the relations between the elements in the group. In ammonium nitrate, the H, although electro-positive, follows negative N, thus, NH_4NO_3 , because we can better realize the relation that really exists between the two radicals NH_4 and NO_3 , which form the molecule in question.

By referring to the few preceding formulæ we perceive the rule is observed, H is electro-positive to Cl; Na to C and O; Na to Cl; H to O; and C to O.

In naming the compounds of inorganic chemistry, we shall employ the full name of the positive element, preferring the noun to the adjective, as more euphonious. Where the compound is made up of elements which unite with each other in only one proportion, that is, form but one compound, the final syllables in the names of the electro-negative elements are changed into *ide*. H and Cl unite with each other only in this proportion, $\text{H}^1\text{Cl}^{3.5-5}$; hence the name of such compound is *hydrogen chlo-*

ride. K and I form but one compound, KI, its name is evidently *potassium iodide*, etc. When two elements unite with each other in *more* than one proportion, the distinctions are made by employing the Greek numerals, *mon*, *di*, *tri*, etc., to indicate the number of atoms or radicles in the molecule. H and O form two compounds, H_2O and H_2O_2 ; the first formula may be called hydrogen *monoxide*, the second hydrogen *dioxide*, signifying *one* atom of oxygen and *two* atoms of oxygen respectively. The *binary* compounds of N and O furnish perhaps the best example of these distinctions:

N_2O	N_2O_2	N_2O_3	N_2O_4	N_2O_5
Nitrogen	Nitrogen	Nitrogen	Nitrogen	Nitrogen
Monoxide.	Dioxide.	Trioxide.	Tetroxide.	Pentoxide.

The *name* alone, therefore, indicates the number of O atoms in each molecule; and they are all equally *dinitrogen oxides*.

There are also different terminations in the name of the positive element, to indicate the least or greatest relative proportion of the *negative* element in the series. In these nitrogen oxides, for instance, the lowest or *mon* (one) oxide is most frequently called *nitrous oxide*, and the highest, or *pent* (five) oxide is known as *nitric oxide*. The prefix *hyper* (reduced sometimes to *per*) meaning *above*, is found convenient to apply to the name of

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a compound containing more of the negative element than exists in a previously named compound of the same elements. Thus nitrogen dioxide might be named as *hypernitrous* oxide. The prefix *hypo*, meaning *under*, might, on the same principle, be applied to nitrogen tetroxide, and the latter named *hyponitric* oxide. These rules apply to any series of compounds made up of the same two elements.

CHAPTER VII.

NOMENCLATURE.

The names of compounds more complicated in the number of their elements than those mentioned in the preceding chapter, are, in inorganic chemistry, derived mainly, from their composition. Let it be understood that *all* acids contain H. *Nitric* acid, as its name implies, contains N. If there be at least three elements in the molecules of acids, a fact which usually obtains, we are safe in assuming that O is the other element, unless the name of the acid is otherwise distinguished. We have, therefore, in the above acid, H and N and O. It remains only to correctly formulate the number of atoms of each, to the molecule, and we accept the proof of analysis and the process known as *equivalent* substitution for this fact. The formula of nitric acid is thus ascertained to be HNO_3 .

Then, there is another oxy-acid of nitrogen; it is named *nitrous* acid— HNO_2 —because it contains less negative O than *nitric* acid.

The names of the other acids are derived in the same way. *Sulphuric* acid, is formulated H_2SO_4 ; *sulphurous* acid, H_2SO_3 ; *chloric* acid, HClO_3 ;

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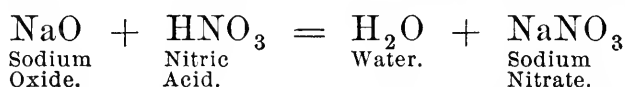
chlorous acid, HClO_2 ; and *hypo*-chlorous acid, HClO , etc.

Acids are classed as electro-negative, in contradistinction to a class of compounds called *bases*. The latter are electro-positive, and many of them are also known as *alkalies*; they are the opposite of acids.

These two classes have a strong love for each other, and combine to form another class of compounds, which have received the general name of *salts*.

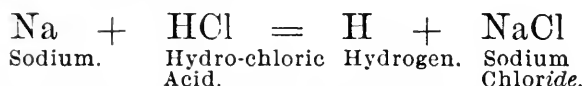
Our conception of chemical *salts*, may be confined for the present, to the simple statement that they are, usually solid, *neutral* substances, produced by the union of acids with alkalies (or bases), and named accordingly.

If *nitric* acid be brought in contact with the alkali—or base—sodium oxide, neutral bodies will result, as will be seen by the following equation:

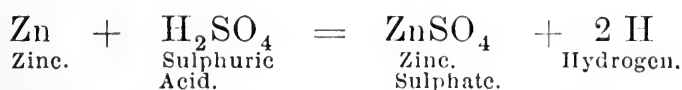


The origin of the names of the first three compounds has already been explained; the last substance, it will be noticed, receives its name by applying the full name of the basic sodium, and changing the final *ic* in the name of the acid to *ate*. The name derived thus, is sodium nitrate. All

salts of nitric acid are nitrates. Salts of nitrous acid are named nitrites. In the same way, all salts produced by the union of *sulphuric acid* with a base are named *sulphates*. Sulphurous acid produces salts called *sulphites*, etc. The names of all salts whose acids contain more than two elements to the molecule, such as HNO_3 , terminate in either *ate* or *ite*; while the names of salts derived from acids whose molecules contain only two elements, end in *ide*. For instance, hydrochloric acid— HCl —*binary*, because made up of only two elements, acting on the basic metal sodium, Na , produces a binary salt whose name should end in *ide*, as will be seen by the following reaction :



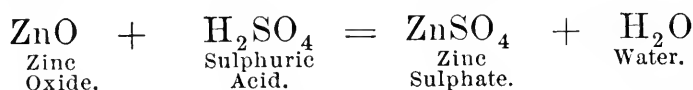
In brief, inorganic salts, whose molecules contain three or more *elements*, have names which end in either *ate* or *ite*, and salts containing but *two elements* have names ending in *ide*. The reaction between an acid and a metallic base, usually consists in the metal taking the place of the H in the molecule of acid, thus :



When the *oxide* of the metal is employed, then, in-

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stead of the H escaping free as a gas, it will unite with the O of the base to form water.



Chemical compounds are definite in their nature, constant in the ratio of their elements. They furnish no evidence, in physical or chemical properties, of their composition, except by analysis. Not so with mere mixtures, water and alcohol may be mixed in any proportion, the mixture exhibiting properties intermediate between those of its constituents, showing regular gradation according to the relative amount of water and alcohol that may be mixed together. A mass of pure water is a chemical compound, it is rendered appreciable by our senses, by the union of a great number of molecules of like construction; that is, they are formed by the same kind and number of atoms; two atoms of H, and one atom of O, $=\text{H}_2\text{O}$; and inasmuch as the individual atom has its own fixed and unchangeable weight, it follows that the mass of matter, made up of homogeneous molecules, each having the same kind and number of atoms, *must* be definite in its nature and constant in the ratio of its elements.

When two or more compounds are made up of the same elements they do not blend imperceptibly into each

other, as in the case of mixtures. Even though their molecules may differ in constitution, by only one atom of the same element, their chemical nature is divided by a sharp line of demarcation; they are separated, as it were, by an impassable gulf; and the compounds themselves show no properties that would leave us to suspect the presence of their constituent elements. Their composition is ascertained by analysis, and proven by synthesis. Carbon-monoxide, CO , and carbon-dioxide, CO_2 , differ only by one atom of O, and yet they are not at all alike, chemically. The first is lighter than air, it is highly combustible, and is not absorbed by a solution of potash. The second is heavier than air, it is not a combustible, and is readily absorbed by a solution of potash, and neither indicates, in the slightest degree, that it is really a compound of C and O. One more example of, perhaps, more familiar substances, may better explain the foregoing statement. Mercury and chlorine form two compounds; mercuric chloride (HgCl_2), is soluble in water; it is a strong corrosive poison, one centigram (1-6 grain) might prove a dangerous dose to an adult. Mercurous chloride (Hg_2Cl_2) is not soluble in water; it is a comparatively mild medicine, one hundred centigrams (15 grains) might be taken without danger.

They are commonly named, corrosive sublimate and calomel, respectively. Their molecules differ, as you perceive, by only *one* atom of Hg, and they exhibit no properties by which we could suppose that mercury and chlorine are the elements in their composition.

We shall consider other important facts in chemical philosophy after we become acquainted with the principal non-metallic or electro-negative elements. These, as a class, are more important, from a chemical standpoint, than are the metallic elements, inasmuch as one at least, of the former, is a necessary constituent of all chemical compounds. Their introduction, together with the leading compounds which they form with each other, will be in the order best adapted, we think, to promote an intimate and pleasant acquaintance with them.

CHAPTER VIII.

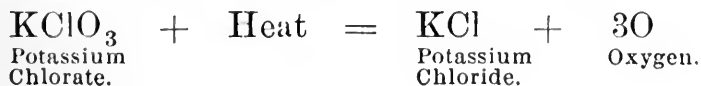
OXYGEN.

Symbol, O. At. wt. 16. Sp. gr. 1.1056.

Oxygen is a colorless, tasteless, and odorless gas. It is the most abundant of the elements. It exists free in the atmosphere, of which it forms about one-fifth part, and of which it is the active element. Combined with other elements, it constitutes about one-half the weight of the solid crust of the earth, and eight-ninths of the weight of water. It is also found as an important element of animal and vegetable tissues.

Oxygen was discovered by Priestly and Scheele in 1774, independently of each other. It can be obtained from any of its compounds, but only those which can give it up cheaply and in large volume are the ones employed for such purposes.

The favorite method is to heat the salt, potassium chlorate, in a retort, and collect the escaping gas over water. We do not regard a detailed description of experiments necessary here, inasmuch as they are fully explained by the teacher.



All the O in the salt is thus driven off by the heat, leaving a residue in the retort composed of K and Cl. If three-fourths, by weight, of potassium chlorate be mixed with one-fourth of an oxide, such as ferric oxide, cupric oxide, or better, manganese dioxide (MnO_2), decomposition will result at a lower temperature, although either of the latter substances does not itself suffer decomposition. Its influence is said to be due to catalytic action (?); a question not fully understood.

Oxygen combines, either directly or indirectly, with all the other elements, except fluorine, to form *binary* compounds; (i. e., H_2O , CaO , Au_2O_3 , etc.).

When a single element unites with O, it is said to be *oxidized*, and the process is called *oxidation*.

Oxidation, like other chemical action, always develops heat. When heat and light are both developed by the process, the body is said to *burn*. The process of combustion will be sufficiently described in connection with the element carbon. Ordinarily, when a body burns, its elements are simply uniting rapidly with the O of the air. Bodies which burn in the air do so with much greater energy in oxygen alone. If pieces of burning charcoal or sulphur, or phosphorus, be placed in a jar of oxygen, the immediate rapid increase in the amount of heat and light is remarkable. If a

candle with a glowing wick be plunged into a vessel full of oxygen, the candle will at once burst into a flame. Certain substances, which do not ordinarily burn in the air, will do so readily in oxygen. A thin piece of iron or steel, such as the rubber saw of the dental laboratory or a broken watch-spring, its surface previously brightened by sand paper, and having attached to the lower end a bit of burning match, or spunk, or sulphur, placed thus in a jar of pure oxygen, will become ignited, and evolve exceedingly brilliant corruscations of heat and light.

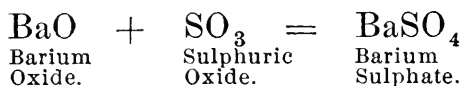
The oxygen of the air, although weakened by its mixture with nitrogen and other gases, is the supporter of ordinary combustion. It is also the supporter of animal respiration; we inhale it with every breath, and alternately exhale the products which are formed by it in the body and which are carried, by the venous circulation, to the lungs, to be expelled.

The name oxygen, from two Greek words, meaning a generator of acids, was given it by Lavoisier, in 1778, who was the first to describe the important part which oxygen plays in the field of natural phenomena.

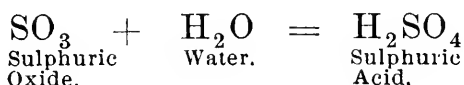
It is a necessary element in the formation of nearly all acids. If we examine with litmus test

paper, the jars in which were burned the sulphur or phosphorus, we will detect an acid reaction: not so the contents of the jar in which the iron burned; the latter fact indicating that all oxides are not of an acid nature. It is only some of the oxides of the non-metallic elements, or those of the metallic elements bordering on the non-metallic, which are classed as acid.

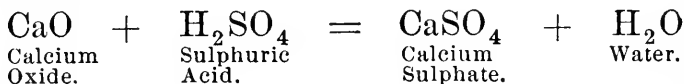
These oxides of the more highly electro-positive of the metals, such as barium, potassium, etc., are always *basic* or the opposite of *acid*. Barium oxide and sulphuric oxide will combine directly under the influence of heat, and thus form the salt known as barium sulphate.



The acid oxides unite with water to form acids, as:

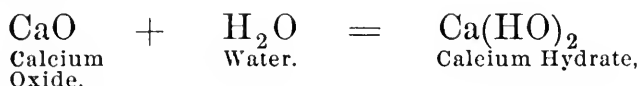


Basic oxides react with acids to form corresponding salts, as:



There is a third class of oxides called *neutral*, of which water is a good example. They are neither acid nor basic, but some of them may act in either

capacity, according to circumstances. When calcium oxide, which is strongly basic, is mixed with water, the latter acts as an *acid* oxide, resulting in the production of the salt called calcium hydrate, or hydroxide.



It will be seen, on the contrary, by referring to the proper equation preceding, that water acting on SO_3 takes the part of a *basic* oxide, in forming the molecule of sulphuric acid, or hydrogen-sulphate (H_2SO_4).

OZONE.—When an element is capable of existing in more than one state it is called *allotropic*. Oxygen is an allotropic element. It exists in a *passive* and in an *active* state. Passive oxygen is the kind we have been studying. Active oxygen is named *ozone*. The latter substance is far more energetic as an oxidizing agent than ordinary oxygen. It is the great natural disinfectant, destroying by oxidation the infectious matter that appertains to the metamorphosis of animal and vegetable tissues. Ozone is developed in a variety of ways:

1st. By heat; as when platinum wire is merely heated in the air.

2nd. By light; as when CO_2 is decomposed by living plants, by the aid of sunlight; and when

essential oils are exposed to sunlight and summer temperature.

3d. By electricity; as when the silent electric discharge takes place in the air, or in oxygen gas, and by electrolysis of water.

4th. By slow oxidation; as when a clean stick of phosphorus is partially exposed to the air, or when a strongly heated glass rod is placed in vapor of common ether.

5th. By rapid combustion; as when a vigorous blast of air forces the top of a Bunsen flame into a large beaker, the contents of the beaker will give the ozone reaction.

A good test for the presence of ozone is paper moistened with dilute solution of potassium iodide (KI) and starch. The ozone, by uniting with the potassium, sets the iodine free, which turns the starch to a deep blue color.

Ozone is an irritating poison to animal tissues, if inhaled in quantity. Unlike ordinary oxygen, ozone has a decided odor, hence its name, which means to smell. It is one-half as heavy again as oxygen; its density being 24, and that of the latter 16. In fine, ozone is oxygen modified into a condition of intense activity. All its combinations with other individual elements produce only *oxides*.

CHAPTER IX.

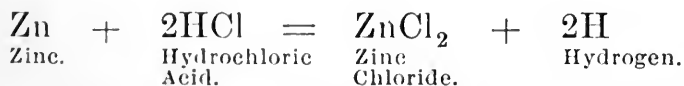
HYDROGEN.

Symbol H. At. wt. 1. Sp. gr. 0.0693.

Hydrogen is a colorless gas, without taste or smell. It is the lightest body known, being about fourteen and a half times lighter than air. The spectroscope shows that hydrogen is a constituent of the sun, the fixed stars and, largely of the celestial nebulæ. It is found *occluded* in meteoric iron.

Hydrogen is found free in volcanic gases. Combined with oxygen, it forms the compound *water*; hence its name, given it by Lavoisier, signifying "generator of water." It is an important element of animal and vegetable tissues, and of mineral oils.

Hydrogen was known in the sixteenth century, but was first accurately described by Cavendish in 1766. It can be obtained from its compounds by various methods, but is usually prepared by action of zinc, on dilute sulphuric acid, or hydro-chloric acid.



The gas may be collected over water or by dis-

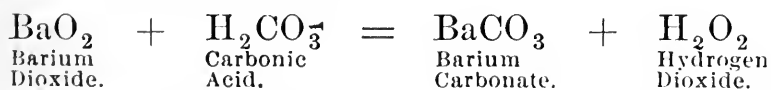
placement of air. Although hydrogen is the lightest substance known, it is undoubtedly the vapor of a highly volatile *metal*. We describe it thus early, in connection with the non-metals, because of the wonderfully important place it holds in the family of elements. On account of the high diffusive power and combustibility of hydrogen, great precaution should be observed in experimenting with the gas, in order to avoid the danger of *explosion*. Heated to a temperature of about 500°C . (932°F .), it unites with oxygen: the union of these gases developing the highest temperature produced by chemical action. One gram of hydrogen in oxidizing, or burning, will raise the temperature of 34,462 grams of water from 0° to 1° ; that is equal to 34,472 *heat units*. The compound which it forms by direct union with oxygen is water (H_2O), the molecule of which contains two parts by weight, or *two atoms* of hydrogen, and sixteen parts by weight, or *one atom* of oxygen. The *molecular* weight of any substance is the sum of the atomic weights, and inasmuch as the two atoms of hydrogen weigh two, and the one atom of oxygen weighs sixteen, the molecular weight of water must be $2 + 16 = 18$.

Water is the most abundant of chemical compounds. Notwithstanding its neutral nature, being

neither acid nor alkali, it is a very active substance, chemically. It leads all other liquids as a solvent. With but few exceptions, solids will dissolve more easily in warm than in cold water, while certain gases, as O , N_2O , CO_2 , etc., are more soluble in cold water than in warm.

Pure water is tasteless, odorless, and, when in small quantity, colorless. It exists in certain compounds as water of *crystallization*, enabling them to assume a definite crystalline form, as, natural gypsum, blue-stone, etc. When sufficiently heated, this water is driven out, and the substance loses its crystalline form, but will take up water again most readily, as in the case of plaster of paris.

Oxygen and hydrogen may be induced to unite in the proportion of *two* atoms of each, to form hydrogen dioxide (H_2O_2), commonly called peroxide of hydrogen. It may be prepared by acting on barium dioxide, held in suspension in water, by either of several acids, as :



Approximately pure, peroxide of hydrogen is colorless; it possesses, however, an ozone-like odor and a peculiar metallic taste. It is never used in medicine, or the arts, in the undiluted form, but is usually held in solution in glycerine or water. A

“ten volume ” preparation of it will give off ten times its own volume of free oxygen. The temperature of summer heat will cause the molecule (H_2O_2) to decompose, one of the O atoms escaping. The solution should, therefore, be kept in a cool place, except when in use.

It is an excellent germicide and disinfectant, destroying the infectious matter by the activity of the *nascent* oxygen which it supplies.

An element is *nascent* at the time it is set free from combination, and is then more anxious to unite with other bodies than when it is in its ordinary state.

A trace of acid (sulphuric or phosphoric) is usually found with the peroxide of hydrogen solution, to render the preparation more stable; and the results of experiments with the peroxide on pus, bone, etc., are often misjudged on account of the acid present.

CHAPTER X.

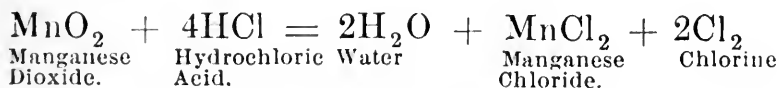
CHLORINE.

Symbol, Cl. At. wt. 35.5. Sp. gr. 2.46.

Chlorine was discovered by Scheele, in 1774. Its elementary character was proven by Davy, in 1810, who gave it the name it bears, which signifies its color, "*greenish yellow*."

Chlorine is not found free in nature. It exists abundantly, however, in combination with Na., Ca., K., and Mg., in sea water, and saline springs. Vast deposits of solid sodium chloride, or common salt, are found and mined; it being a necessary article of every day use.

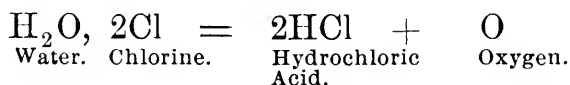
Chlorine is usually obtained in quantity by gently heating together certain proportions, indicated by their molecular weights, of the two first following compounds:



It may also be obtained, sufficiently pure for ordinary experiment, by acting on common bleaching powder with dilute sulphuric acid. The reaction of these substances, being rather complicated, will not be considered at this time.

Chlorine is a greenish-yellow gas, of an intolerable suffocating odor and astringent taste. When subjected to a cold of 40° , or at a common temperature, to a *pressure* of four atmospheres—60 pounds to the square inch, it condenses to a yellow liquid of sp. gr. 1.38.

Water will dissolve nearly three times its own bulk of chlorine, the solution acquiring the color and odor of the gas; it is known as *aqua chlori*, and is employed to advantage in practice, as a disinfectant, and to bleach discolored teeth. *Aqua chlori*, exposed to the influence of light, decomposes according to the following equation:



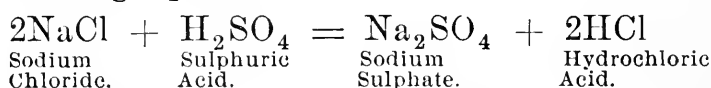
It must, therefore, be preserved in a dark place. Chlorine acts indirectly as a bleaching agent and disinfectant through its love for the hydrogen of water, letting the O go free, *vide* the above equation, which latter element, in its *nascent* state, attacks the coloring matter, or infectious matter, as the case may be, forming with either, new compounds that are destitute of color, or free from the germs of disease. Mineral colors, as a rule, are not affected by chlorine.

The affinities of chlorine are exerted mainly toward hydrogen and the metals. If a lighted

candle, the combustible elements of which are C and H, be placed in a jar filled with chlorine, dense volumes of smoke will be evolved, owing to the chlorine taking up with the H of the candle, resulting in HCl, and the rejection of the C, which escapes as smoke. A piece of tissue paper moistened with *warm* oil of turpentine, and thrust into a jar of chlorine, shows the same phenomenon. Finely divided arsenic, or antimony, or thin leaves of copper or bronze, or a bit of phosphorus, at ordinary temperatures, and sodium, at a higher temperature, will burn in chlorine, forming a chloride in each case. A mixture of hydrogen and chlorine, exposed to the sunlight, will unite with explosive violence. In fine, chlorine unites, either directly or indirectly, with all the elements, forming a *chloride* with each, some of which, however, are very unstable compounds.

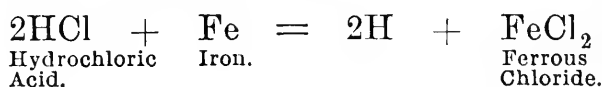
HYDROGEN CHLORIDE.—Chlorine and hydrogen unite with each other in but one proportion. The compound is generally called hydrochloric acid. It is a colorless gas, of a pungent odor, is irrespirable, though not so irritating as chlorine, and is noncombustible. Its specific gravity is 1.264, its density (H as unity) is 18.25. Subjected to cold and pressure, it condenses to a colorless liquid, of specific gravity 1.27.

Hydrochloric acid is manufactured on a large scale by heating together quantities of common salt (NaCl) and strong sulphuric acid, as indicated by the following equation :



The gas (HCl) is very soluble in water. A given volume of water will dissolve 450 volumes of the gas, and a more or less saturated aqueous solution becomes the hydrochloric or muriatic acid of commerce, possessing the same acid and acid properties of the gas itself. The presence of the water, however, is not expressed in the reactions of the acid, so that the formula HCl means either the gas alone, or its solution in water.

Hydrochloric acid is an important substance. It dissolves many of the metals, such as aluminum, tin, iron, zinc, etc., the reaction consisting in the metal supplanting the H of the acid, resulting in free hydrogen and metallic chlorides. As before alluded to, as a rule, with some exceptions, whenever any acid attacks a metal, a quantity of H equivalent to the metal escapes free, the metal uniting with the residue of the acid to form a salt of the metal in question, as :



Hydrochloric acid is therefore the type of all *chlorides*.

It is one of the solvents in the gastric juice, and is probably developed there by the influence of a special ferment, which, in some way not yet understood, induces the Cl of the sodium chloride, one of the proximate principles of the body, to unite with the H of the water present, or some other hydrogen compound, or *vice versa*. The child of the union would, of course, be HCl.

Dr. George Watt, of Ohio, the recognized originator of the chemical (*per se*) theory of dental decay, proposes hydrochloric acid as the active cause of the *brown*, or common variety of decay of teeth.

The structure of a tooth is generally divided into animal (matrix) and mineral portions; the latter consisting mainly of calcium phosphate and calcium carbonate.

If hydrochloric acid is formed in the mouth, in accordance with the affinities by which it is developed in the gastric juice, a chemical analogy by no means improbable, the *nascent* individual molecules of the acid would simultaneously *decompose* the calcium carbonate, and *dissolve* the calcium phosphate.



The calcium phosphate of the tooth, although not entering into the equation, loses its structural integrity by solution, and the animal portion more or less remains *in situ*.

There are compounds of chlorine, hydrogen, and oxygen, the elements we have especially introduced thus far, which are worthy of some consideration at this time. They are all acid in their nature, and may be regarded as *oxides* of HCl:

HClO_4 , Perchloric acid.

HClO_3 , Chloric acid.

HClO_2 , Chlorous acid.

HClO , Hypochlorous acid.

The salts of these acids are known, seriatim, as perchlorates, chlorates, chlorites, and hypochlorites. The first and third class are of no special interest, but the chlorates and hypochlorites are used largely as important agents in chemistry and materia medica; they will be considered later on in connection with certain metals. There are three oxides of chlorine, Cl_2O , Cl_2O_2 , Cl_2O_4 , which are highly explosive, but possess no other interest.

Chlorine is the principal member of a group of elements which contains also iodine, bromine, fluorine. They are all called *halogen* elements, because the sea is the principal source of chlorine, iodine,

and bromine; so great is the resemblance to each other, in their chemical nature, that a description of one, as, for instance, chlorine, will serve in a measure for that of the others.

CHAPTER XI.

IODINE.

Symbol, I. At. wt. 127. Sp. gr. 4.95.

Iodine is obtained from the ash of sea weeds. It is a dark bluish solid, consisting of rhombic scales, of a metallic luster. It melts at 107° (225° F.), and boils at 180° (356° F.), evolving a magnificent violet vapor, of specific gravity 8.72.

Iodine requires 7,000 parts of water to dissolve it. It is freely soluble in an aqueous solution of its most important compound, potassium iodide, and in alcohol, ether, chloroform, and carbon disulphide. It is not as active, chemically, as chlorine, though it combines directly with most of the metals forming *iodides*. It strikes, with a solution of starch, a deep blue color, so intense that one part of iodine in 300,000 of water can be detected by the starch test.

Iodine, both free and in combination, is a valuable therapeutic agent,* as a resolvent and antiseptic; it is also largely used in photography.

*Brief allusion to medicinal qualities, while considering the non-metallic elements, is excusable, as we hope to deal justly by their compounds in *materia medica*.

BROMINE.

Symbol, Br. At. wt. 80. Sp. gr. 3.187.

Bromine is prepared from sea water and saline springs. It is a red-brown liquid of disagreeable odor, hence its name. Heated to a temperature of 63° (145°F.), it boils, yielding a deep red vapor, of specific gravity 5.5. Cooled to -22° (-8°F.), it becomes a crystalline lead-gray solid. One part of bromine requires 33 parts of water to dissolve it. It is a corrosive poison; exerts a strong bleaching power. It is, chemically, less active than chlorine, but more so than iodine. Some of the metals will burn in its vapor, producing bromides. It is used extensively in photography, and some of its compounds are of therapeutic value.

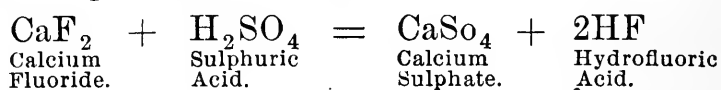
FLUORINE.

Symbol, F. At. wt. 19. Sp. gr. —.

Fluorine is a constituent of a substance known as fluor spar, meaning, I flow, because this compound— CaF_2 —is used as a flux in the reduction of some metals.

Free fluorine (but recently isolated) is a colorless gas, of pungent odor, and exceedingly corrosive.

It is especially distinguished as the only element which refuses to unite with oxygen; and although in its free, and therefore *inactive* state, it shows only slight affinity toward silicon, the latter element is violently attacked by *nascent* fluorine, which is developed by bringing together hydrofluoric acid and a silicon compound, such as glass. Hydrofluoric acid, HF, is usually prepared by reaction of calcium fluoride and sulphuric acid, in a vessel of platinum or lead.



This acid, when pure, is a colorless gas, but in its ordinary condition it is dissolved in water. It is of peculiar interest, because it is the only substance that freely attacks such compounds of silicon as glass, and porcelain teeth. It is useful in the arts, for etching on glass.

HALOGEN ACIDS.

The analogy between the halogen elements, chlorine, iodine, bromine, and fluorine, is best exemplified by their binary *hydrogen* compounds:

Hydrochloric acid.. ..	HCl
Hydriodic acid.....	HI
Hydrobromic acid.....	HBr
Hydrofluoric acid.....	HF

The first and last of these acids have already been sufficiently described. The second (HI) and third (HBr) are also pungent, colorless gases, very soluble in water, and are used in practice in aqueous solution. They are the prototypes of all iodides and bromides, as hydrochloric and hydrofluoric acids are the types respectively of chlorides and fluorides. There are also oxy acids of iodine and bromine analogous to those of Cl. The principal ones have the formula of HIO_3 and HBrO_3 , corresponding to chloric acid HClO_3 . Their salts are called iodates and bromates.

CHAPTER XII.

NITROGEN.

Symbol, N. At. wt. 14. Sp. gr. 0.971.

Nitrogen is a colorless, odorless, and tasteless gas. It was discovered by Rutherford in 1772, and received its name because it was found to be a necessary constituent of niter.

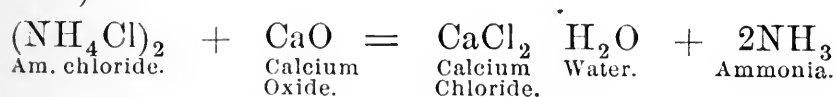
Nitrogen and oxygen are the principal components of the atmosphere; four-fifths of nitrogen, and one-fifth of oxygen. Although not chemically combined, their intimate mixture in the above proportions obtains throughout, the nitrogen serving to retard within reasonable bounds the energy of oxygen.

If a piece of phosphorus be burned in a given volume of air, confined over water, the phosphorus takes up all the oxygen, the water rapidly absorbs the compound so formed, and the nitrogen remains alone, comparatively pure.

Nitrogen is not a supporter of combustion, nor of respiration; it is, in fine, remarkably inert, showing little disposition to unite directly with other elements, although its compounds are numerous, and some of them of exceeding energy.

Besides its existence in the atmosphere, it is found in nature in the compounds known as nitrates, and in ammonia, and is also an essential element of certain animal and vegetable substances.

AMMONIA.—Ammonia is a gaseous compound of nitrogen and hydrogen (NH_3). It is formed slowly at common temperatures, by putrefactive decomposition of animal and vegetable substances containing nitrogen; more rapidly when clippings of horns, hoofs, or hides, or other animal tissue, are subjected to heat—hence the name sometimes given it of “spirits of hartshorn.” Many of its compounds are now obtained by the destructive distillation of coal, in the manufacture of illuminating gas. Ammonia itself is prepared by gently heating together a salt known as “sal ammoniac,” or ammonium chloride, and calcium oxide (quicklime).

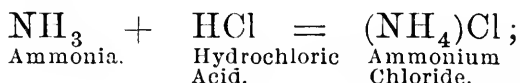


Ammonia is a colorless gas, of specific gravity 0.59. It is possessed of a peculiar pungent odor, by which its presence may be detected. Subjected to a pressure of a hundred pounds to the square inch, at 10° (50°F.), it condenses to a clear liquid, of specific gravity 0.76. The liquid ammonia is highly volatile, and in passing into the gaseous

state, by removal of pressure, it absorbs a large amount of heat. It is for this reason, as well as its cheapness, that ammonia is employed in the artificial production of ice.

Ammonia gas is exceedingly soluble in water; one volume of water at 15° (59°F.) will dissolve 783 volumes of the gas. This solution, further diluted, is the well known "aqua ammonia" of commerce. It evolves the gas again upon heating, or on exposure to the air. It is a stimulant when slightly inhaled, and is often so employed in non-complicated syncope.

Ammonia, whether in the gaseous form or in the aqueous solution, is strongly alkaline; it unites with and neutralizes the strongest acids, forming with them compounds, called salts of ammonia. The hydrogen of the acid, in such combination, is not driven out, but seems to take up intimately with the ammonia itself, apparently producing, in the reaction, an unsatisfied group (NH_4), which has received the name of ammonium, because it acts in many cases like an atom of some of the metals. Thus:



analogous to sodium chloride, NaCl . Ammonium chloride was first prepared by the Arabs of the

Libyan deserts, as a substitute for common salt, by heating camel's dung. They named it "sal ammoniac"—salt of Ammon—in honor of Jupiter Ammon, whom they worshiped, and from which the name *ammonia* is derived. Ammonium iodide and ammonium bromide are analogous salts.

Nitrogen and oxygen unite with each other in five proportions. Their compounds have the following names and formulas :

Nitrogen pentoxide (or nitric oxide)..... N_2O_5

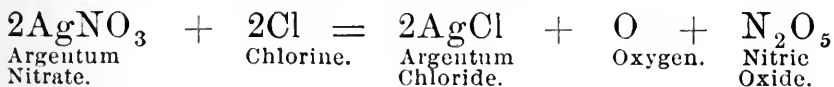
Nitrogen tetroxide..... N_2O_4

Nitrogen trioxide..... N_2O_3

Nitrogen dioxide..... N_2O_2

Nitrogen monoxide (or nitrous oxide).... N_2O

The first and third are acid oxides; they will combine with water to form acids. Nitric oxide, sometimes called nitric anhydride, may be prepared by action of chlorine on solution of silver nitrate :



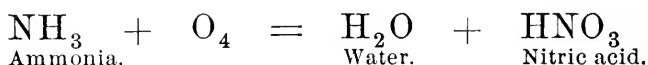
Nitric oxide is a colorless crystalline solid, of unstable, explosive qualities. It reacts energetically with water, producing nitric acid :



Nitric acid was known to Geber in the eighth century, and described by Raymond Lully in 1225. Cavendish, in 1785, first determined its true compo-

sition. It is formed in nature in various ways ; by strong electric currents passing through air ; by ozone acting upon the nitrogen, or the ammonia in the air, or on nitrogen dioxide, trioxide, and tetroxide, in the presence of water.

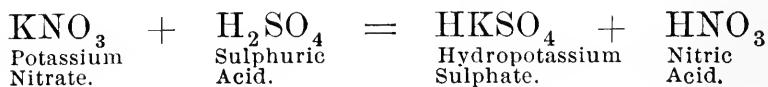
When animal or vegetable matters containing nitrogen decompose, ammonia is produced, and this compound, in presence of weak alkaline bases, is decomposed by nascent oxygen, or by ozone, into water and nitric acid :



A process of manufacture, following these lines, will result in the development of artificial beds of *niter*.

In the arts, however, nitric acid is always produced by heating sulphuric acid with either potassium nitrate or sodium nitrate.

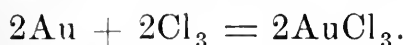
An equation will best explain the reaction :



Nitric acid, commercially known as *aqua fortis*, when pure, is a fuming, colorless, corrosive liquid, having a specific gravity of 1.52 ; chemically, it is an exceedingly energetic body, attacking most of the metals, and forming with them salts called *nitrates*, nearly all of which are soluble in water.

Nitrogenous animal substances, as wool, silk, and parchment, are colored a deep yellow by it. And many non-nitrogenous substances, as cotton, sugar, and glycerine, are converted into explosive bodies by nitric acid.

By virtue of its oxidizing power, many remarkable reactions are induced to take place. Gold is not affected by any single acid, except slightly by selenic acid, but if the two acids, hydrochloric and nitric, be mixed and gently heated, the nitric acid will give up enough oxygen to oxidize all the hydrogen of both acids, setting the chlorine free, which latter element, in its nascent state, readily unites with the gold present, forming the soluble AuCl_3 .



The NOCl is of no importance, some authorities claiming that the residue of nitrogen and oxygen remain together as 3NO , letting all the chlorine escape to the gold.

Nitric acid is believed by many experimenters to be the cause of the rapid, or white, variety of decay of teeth. This idea does not conflict in the least with the so called "germ theory" of decay, inasmuch as the ferment of nitric acid has been discovered recently. The manner of its formation in the re-

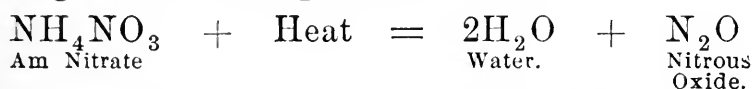
cesses of the teeth, as described by Dr. Watt, is owing to the decomposition of nitrogenous substances (putrefaction), developing simultaneously ammonia and nascent oxygen, which immediately react on each other, resulting in the oxidation of the hydrogen and nitrogen into nitric acid. The action of any acid on the tooth, in forming caries, must occur at the place, and at the instant, of its development; that is, *molecularly*. It is not conceived that caries are formed only by a general acid nature of the oral fluid; on the contrary, the latter may remain neutral, or be even decidedly alkaline. The favorite trysting place of the ferments, in dental caries, is usually a quiet nook, unfrequented by the brush, where the cultures consisting of organized debris, are changed into simpler bodies, and many of these, ultimately, into poisonous ptomaines and acids.

Little need be said of the dioxide, trioxide, and tetroxide of nitrogen. The dioxide (N_2O_2) is able to take up oxygen from the air and is thereby converted into the tetroxide, N_2O_4 ; the latter substance is a good oxidizing agent, as we shall learn by and by. The trioxide (N_2O_3) is the *anhydrous* oxide of *nitrous* acid, as the pentoxide (N_2O_5) is of *nitric* acid; the salts of nitrous acid are called nitrites, as those of nitric acid are called nitrates.

NITROUS OXIDE.—Or nitrogen monoxide. Molecular formula, N_2O . Sp. gr. 1.527.

Nitrous oxide was discovered by Priestly in 1776. Sir Humphry Davy, in 1807, described its exhilarating properties, and in 1845 Dr. Horace Wells, an American dentist, of Hartford, Conn., employed it as an anæsthetic, and in so doing, became the original, genuine discover of *anæsthesia*.

Nitrous oxide is prepared by carefully heating in a retort the salt known as ammonium-nitrate. The retort is connected by means of glass and rubber tubing with a series of wash bottles, the tube ending in a receiver placed over water :



The wash bottles usually contain water, potassium hydrate, and ferrous sulphate; these substances neutralize any traces of the higher oxides of nitrogen that may be evolved, and which otherwise would pass through with the nitrous oxide into the receiver.

Nitrous oxide is a colorless, odorless gas, with a slightly sweetish taste. Subjected to a pressure of 45 atmospheres at 0° (32°F.), it condenses to a clear, mobile liquid of specific gravity 0.9; this liquid freezes into a snowlike mass, by the effect of its own evaporation, when allowed to escape freely

into the air. Its boiling point is -88° (-126°F.); its freezing point is -101° (-150°F.).

The gas is quite soluble in alkaline solutions; it is also soluble in water; more so in cold water than in warm; 100 volumes at 15° (60°F.) will dissolve 78 volumes of the gas. It possesses decided disinfectant and antiseptic properties. Impure water, containing much organic matter, becomes pure and sweet, and remains so indefinitely, after dissolving even a small quantity of the gas.

Nitrous oxide is readily decomposed by the heat of burning bodies, letting its oxygen go to support the combustion. In this way combustible bodies will burn in it, much like we saw them do in oxygen, with greater energy than in the air. In this way, also, it supports animal respiration to a certain point. One of the products it develops in the body (CO_2) can not escape, as in ordinary breathing; the unavoidable retention, therefore, of this product, in the central and other capillaries, induces more or less asphyxia, according to the quantity and rapidity of the inhalation of the un-mixed gas.*

Nitrous oxide is now largely supplied to the profession, condensed to the liquid state in metallic cylinders.

* The possible chemico-physiological action of nitrous oxide will be considered with the compounds of iron.

CHAPTER XIII.

SULPHUR.

Symbol, S. At. Wt. 32. Sp. gr. 2.04.

Sulphur (brimstone) has been known from the earliest historic ages. It is found free in certain volcanic regions. It is found also in nature in combination with other elements, as iron, copper, mercury, zinc, lead, arsenic, antimony, and hydrogen. The *sulphides* are important natural compounds, and with oxygen and certain metals, such as calcium, magnesium, barium, strontium, and sodium, it is found in the class of salts known as *sulphates*. Sulphur is an essential element of animal bodies, and of many vegetables.

It is a yellow, brittle solid, freely soluble in carbon disulphide, but not in water; it melts at $114^{\circ}(237^{\circ}\text{F.})$, and boils at $448^{\circ}(824^{\circ}\text{F.})$; it is tasteless and odorless, and is not a conductor of heat or electricity.

Sulphur is capable of crystallizing in two distinct forms; it is, therefore, said to be *dimorphous*. The natural crystals, and those deposited from solution of the element in carbon disulphide, are rhombic octohedra, while melted sulphur, if allowed to

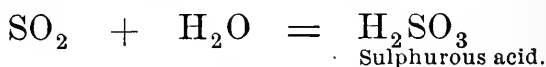
cool slowly, will assume a prismatic form. An *amorphous* (non-crystalline) variety is obtained by pouring melted sulphur into cold water.

When heated in the air to 260° (500°F.), sulphur takes fire, and burns with a pale, lambent flame, forming SO_2 ; and certain metals, if heated in its vapor, will burn readily, forming sulphides. It, therefore, shows an affinity for oxygen and various metals; it also unites directly with carbon.

Dental rubbers contain from 15 to 20 per cent of "flowers of sulphur," which enables the caoutchouc to become vulcanized into a hard material. Sulphur has been suggested as a filling for root canals, being fused therein by heated instruments, and for setting crows.

Sulphur unites with oxygen in two proportions. When sulphur is burned in the air, or in oxygen, the dioxide (SO_2) is formed; this substance is a good disinfecting and bleaching agent, being a deoxidizer, able to take away oxygen from certain deoxidizable bodies, which destroys their identity.

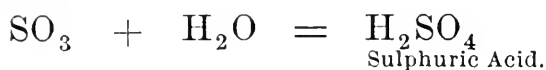
Sulphur dioxide is an acid oxide; united with water, sulphurous acid is the result:



The salts of this acid are named *sulphites*.

The other oxide of sulphur is the trioxide (SO^3)

or sulphuric oxide. It is usually prepared by oxidizing sulphurous oxide—the dioxide SO_2 . Sulphur trioxide is a white wax-like solid, of a silky, fibrous appearance, somewhat resembling asbestos. It unites with water, giving rise to great heat, producing sulphuric acid:



Sulphuric acid, hydrogen sulphate, next to water itself, is perhaps the most generally useful substance in chemistry: it occurs free in the waters of certain springs and rivers, and in the saliva of certain mollusks, and is the type of all *sulphates*.

The preparation of sulphuric acid—also known as oil of vitriol—involves several simple chemical reactions:

1st. The burning of sulphur in the air to obtain sulphurous oxide SO_2 .

2d. The presence of nitric acid (2HNO_3) which supplies nitrogen tetroxide N_2O_4 .

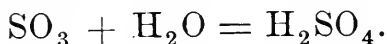
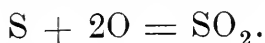
3d. The latter compound gives oxygen to the SO_2 , changing it into SO_3 , and is itself reduced to nitrogen dioxide N_2O_2 .

4th. Water, heated by the burning sulphur, unites with the SO_3 , producing sulphuric acid.

5th. The taking up of oxygen from the air by

the nitrogen dioxide, which thus serves as a carrier of oxygen.

The whole process may be more easily understood by referring to the following equations:



Inasmuch as the process is continuous and simultaneous, from the burning of the sulphur to the deposition of the acid on the floor of the leaden chamber, it is probable that other and complicated reactions take place. The above explanation, however, is the one generally accepted as the simplest view that can be taken in the premises and is, at least approximately, correct.

Sulphuric acid is a colorless, oily liquid, of specific gravity about 1.85. Freezes at -26° (-15°F.) and boils at 328° (622°F.). It has a strong affinity for many of the metals. It is always thirsty for water, their union evolving great heat. It absorbs moisture from the air and from other gases, and is therefore often used as a drying agent. Its general action on organic matters is to dehydrate them, that is, to take from their substance the elements oxygen and hydrogen, and induce them to combine to form water, that its thirst may be satisfied.

Sulphuric acid is more than likely involved in the condition known as "black decay" of teeth. Its production *in situ* is probably due to the energy of nascent oxygen on hydrogen sulphide (H_2S), these being evolved from the organized debris in contact with the tooth, and which is said to undergo decomposition by the influence of some not yet detected special form of bacteria.

The phenomena of "black decay" really seem to be an arrest of the destructive proceedings of some active solvent, previously at work. Any well-marked specimen of this form of caries represents the surface of the cavity of a dark brown or black appearance, hard, and sometimes polished, and which is comparatively immune from further decay. The limiting action of sulphuric acid on tooth structure explains the above physical characteristics. Its molecules, at their birth, attack the earthy portion, forming insoluble calcium sulphate (CaSO_4), and at the same time dehydrating the animal or gelatinous portion, which is mainly made up of carbon, hydrogen, and oxygen; these two latter elements are withdrawn, as already alluded to, leaving the indestructible carbon as a residue, to be incorporated with the insoluble sulphate, producing thus a protecting covering to the unaf-

fects parts beneath against further inroads both of the causing agent and other solvents.

A gaseous compound of sulphur and hydrogen (sulphuretted hydrogen, dihydrogen sulphide, sulphydric acid, etc., H_2S), is found in nature, and also largely employed in the laboratory as an important re-agent in classifying the metals, according as their sulphides are either soluble or insoluble in acid and alkaline solutions.

Quite a number of oxygen acids of sulphur are known as *thionic* acids; their molecules contain 2 atoms of H and 6 of O, and 2, 3, 4, and 5 atoms of S, respectively. They are, however, of no general or special interest to us.

SELENIUM.

Symbol, Se. At. wt. 79. Sp. gr. 4.5.

Selenium, named in honor of the moon, belongs to the less abundant elements. It is occasionally found free, but generally in company with sulphur, and in the selenides of silver, mercury, lead, and copper. It unites with hydrogen to form a gaseous compound (H_2Se), analogous to sulphuretted hydrogen, of an extremely nauseous odor. It forms acids corresponding to those of sulphur: selenious acid (H_2SeO_3), and selenic acid (H_2SeO_4), the latter being the only single acid that will even sparingly attack gold.

TELLURIUM.

Symbol, Te. At. wt. 128. Sp. gr. 6.2.

Tellurium, named from *tellus*, the earth, is a rarer element than selenium. It occurs free in small quantities, and in the tellurides of mercury, silver, lead, bismuth, and gold. In Colorado, the *tellurides* of silver and gold are important ores. Physically, it resembles the metals, but in its chemical nature, it is closely related to sulphur and selenium.

The three elements form similar compounds—with hydrogen (H_2Te), and with oxygen (TeO_2 , TeO_3), and corresponding acids (H_2TeO_3 , H_2TeO_4).

CHAPTER XIV.

PHOSPHORUS.

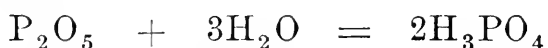
Symbol, P. At. wt. 31. Sp. gr. 183—214.

Phosphorus was discovered by Brandt in 1669. It does not occur free in nature, but exists in combination, generally as phosphates. It is a constituent of teeth, bones, and other tissues, and is obtained in our food, mainly from the seeds of plants.

Phosphorus is prepared from the ash of bones by treatment with sulphuric acid and charcoal. It is a yellow, waxy, translucent solid, easily cut with a knife, is luminous in the dark, by slow oxidation. At 50° (122°F.) it takes fire, and burns with great brilliancy. Its field of energy is very wide, as it combines with nearly all the elements, C and N being exceptions. It is soluble in carbon disulphide, but not soluble in water, in which it must be preserved. As phosphorus is an active, insidious poison, workmen in match factories, by neglecting their teeth, are often afflicted with dental caries and necrosis of the lower jaw. Oil of turpentine and alkaline mouth washes are the best antidotes.

Phosphorus, heated to 250° (482°F.), is converted into a red powder of sp. gr. 214. The red variety is not soluble in carbon disulphide, is not poisonous, has no odor, and does not oxidize in the air, and will not take fire until heated to 260° (500°F.).

There are two oxides of phosphorus: that produced by oxidation, *phosphorous oxide* (P_2O_3), and that produced when phosphorus is burned in the air or in oxygen, *phosphoric oxide* (P_2O_5). Phosphoric oxide, united with water, forms phosphoric acid:



There are several kinds of phosphorus acids, but two or three only need be mentioned.

Ordinary phosphoric acid (H_3PO_4), often called orthophosphoric, is a syrupy liquid, of strong acid properties; its salts are called orthophosphates (as bone phosphate). It forms, with calcined zinc oxide (and also with cupric oxide), a coherent, hard cement, used as a temporary filling, or for strengthening frail walls in cavities of teeth.

As phosphoric acid is formulated from 3 molecules of water, *pyrophosphoric acid* is formulated from 2 molecules, and *metaphosphoric acid* from 1 molecule of water, thus:



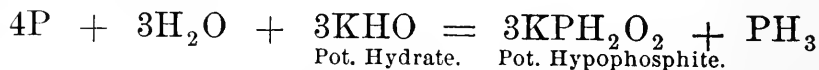
$\text{P}_2\text{O}_5 + 2\text{H}_2\text{O} = \text{H}_4\text{P}_2\text{O}_7$, pyrophosphoric acid;

$\text{P}_2\text{O}_5 + \text{H}_2\text{O} = 2\text{HPO}_3$, metaphosphoric acid.

The salts of the two latter are called pyrophosphates and metaphosphates, respectively. The *meta* acid is also known as glacial phosphoric acid. It is a vitreous solid, readily soluble in water; will coagulate albumen, while the *ortho* variety will not. By the addition of water and a gentle heat, the glacial is converted into the ordinary so-called ortho-phosphoric acid.

Phosphorus and hydrogen unite indirectly, producing a compound phosphine (PH_3), corresponding with ammonia (NH_3), a colorless gas of garlic-like odor. It precipitates several metals from solutions, as phosphides.

Phosphine is usually prepared by filling a flask nearly full of an aqueous solution of caustic potash, to which are added a few bits of phosphorus. The air above the solution in the flask should be driven out by drops of ether or a current of illuminating gas.



The PH_3 is adulterated with traces of P_2H_4 , which, on escaping from the tube in the water pan into the air, causes each bubble of the phosphine

to ignite with a brilliant flash, to form beautiful ascending rings of smoke, consisting of the oxidized phosphorus (P_2O_5).

There are two chlorides of phosphorus, the trichloride (PCl_3) and pentachloride (PCl_5). The pentachloride is a solid substance, and is formed in the experiment showing the spontaneous ignition of phosphorus in chlorine gas.

CHAPTER XV.

CARBON.

Symbol, C. At. wt. 12. Sp. gr. 3-5, 2.15, 1-9.

Carbon is remarkable as existing in nature in three distinct allotropic forms, which have no physical properties in common, but whose chemical nature is the same. These three forms are known as the *diamond*, *graphite*, and *charcoal*. Twelve (12) parts, by weight, of either of these varieties, united with oxygen, give us forty-four parts, by weight of the same compound (CO_2).

Carbon also occurs extensively in nature, as in the carbonates, of which limestone, marble, chalk, and dolomite are examples. It is the characteristic element of animal and vegetable life—all organized tissues contain it—hence *organic chemistry* treats only of carbon in its relations to other elements.

THE DIAMOND occurs in nature in crystals, more or less perfect, derived from the regular octahedron. It is the hardest substance known, and when cut and polished possesses high refractive and dispersive power hence its use as a costly gem. When diamond is heated in a gas incapable

of acting chemically upon it, it swells into a black porous mass resembling coke.

GRAPHITE, or plumbago, also known as black lead, occurs in hexagonal plates, found as an irregular vein traversing ancient slate beds. It is also obtained in brilliant scales from melted cast-iron, on cooling. GRAPHITE has a semi-metallic appearance, an unctuous feel, leaves a mark when drawn on paper, is a fairly good conductor of heat and electricity (which the diamond is not), and is used in the making of lead-pencils (therefore *graphite*), stove polish, crucibles, in electrotyping, and as a varnish for grains of gunpowder.

An impure, quasi graphite, *gas carbon*, formed in the retorts in manufacturing coal gas, is used in galvanic batteries, and for the carbon points of the arc electric light.

CHARCOAL includes all those varieties of coal found in nature, ordinary charcoal (of either animal or vegetable origin), coke, and lampblack.

Coal consists of the remains of vegetable matter that once flourished on the earth's surface, and was subjected to a process of partial combustion, much like that by which common charcoal is prepared; but much of the volatile principles yet remain, made up largely of hydrogen. Cannel and soft coal contain the most hydrogen, and anthracite

the least. The elements, oxygen, sulphur, and nitrogen, are also found in coal, in varying proportions; and likewise earthy substances, which form the ash.

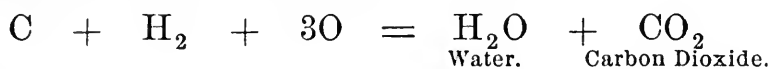
The varieties recognized merely as *charcoal* are produced by imperfect combustion of wood, bones, etc. Nearly all the volatile principles of the original substance are driven out, leaving a porous matrix. The ability of charcoal to absorb certain gases is due to this porosity. Noxious gases, such as ammonia and sulphuretted hydrogen, are absorbed in large quantity by freshly prepared charcoal, which are condensed within its pores and oxidized into harmless compounds by the oxygen which it also absorbs at the same time. In this way charcoal acts as a disinfectant.

Coke is the residue left in the retorts of the gas-works from the destructive distillation of coal.

Lampblack, considered as the purest variety of amorphous carbon, is prepared by burning resin, tar, petroleum, or turpentine, in a limited supply of air, and collecting the smoke in suitable chambers, by which the *soot*, carbon, is deposited. Printer's ink, India ink, and black paint, are made from lampblack.

COMBUSTION.—In the wide sense of the term, combustion means any chemical action that devel-

opes heat *and* light. Ordinarily, however, the meaning is restricted to the burning of substances in the air or in oxygen, and still further restricted by the understanding that the elements of the burning body are mainly carbon and hydrogen. This fact obtains in the burning of coal, or wood, or candle, or coal oil, or illuminating gas; and the chemical action, briefly stated, consists in the union of these elements, C and H, with the O of the air. Sufficient heat must be applied to start the process, which then continues, under favorable conditions, until the materials involved are completely oxidized. An equation will enable us to understand fully, the general reaction:



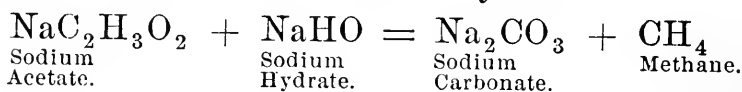
Common combustion may therefore be defined as "consisting of the union of the elements of the burning body with the oxygen of the air, resulting in the formation of water and carbonic acid gas." The earthy constituents of the wood or coal, such as potassium, are also oxidized at the same time, forming the "ash."

Illuminating gas, manufactured by destructive distillation of bituminous coal, is a mixture of free hydrogen, methane, ethene, ethine, and traces of CO, CO₂, N, and H₂S.

Methane, marsh gas, or light carburetted hydro-

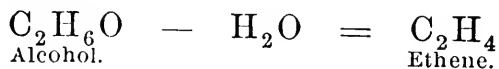
gen, CH_4 , is the lightest body known next to hydrogen, its specific gravity being 0.5576. It occurs free in nature, being produced by decomposition of vegetable matter confined under water, and may be collected by filling a wide-mouthed bottle with water and holding it over the bubbles which rise on stirring with a stick the mud at the bottom of marshy ponds—hence its name, “marsh gas.” It is also the “fire damp” of the miners.

It is usually prepared in the laboratory by heating sodium acetate and sodium hydrate.



Methane is a colorless, odorless and tasteless gas, and burns in the air with a faintly luminous flame.

Ethene, ethylene, heavy carburetted hydrogen (C_2H_4); produced in the decomposition of many organic bodies, is prepared by heating alcohol with strong sulphuric acid, which abstracts the elements of water, thus:



Ethene is a colorless gas, much heavier than methane, its specific gravity being 0.978; it burns with a splendid white flame, and will unite with chlorine ($\text{C}_2\text{H}_3\text{Cl}$) forming an *oily* liquid of ethereal odor, whence the name sometimes applied, “*olfiant gas*.”

The reader will kindly appreciate the fact, that these two gases, CH_4 and C_2H_4 , are fair examples of the hydrocarbons that take active part with the oxygen of the air, in the process of ordinary combustion; and that the products are, necessarily, water, (H_2O), and carbonic acid gas, or carbon-dioxide (CO_2).

The light from burning oil, or candle, or illuminating gas, or at the cheerful fireside, or the open grate, holding either wood or coal, or natural or artificial gas, consists substantially of the same chemical reaction, *i. e.*, the union of hydrogen and carbon with atmospheric oxygen.

A *flame*, therefore, will vary in physical and chemical properties, according to the relative quantities of either the less or more dense hydrocarbon compounds, and the oxygen involved in the process. When the more dense or heavy gases burn in the air, the *light* evolved is superior to that given off by the less dense hydrocarbons, owing to the difference, in affinity, between the carbon and hydrogen of the burning gases, and oxygen.

Burning gases, containing relatively much hydrogen, give off greater *heat*, while those that are relatively rich in carbon are deficient in *heating*, but correspondingly rich in *lighting* power.

The common, everyday hydrocarbon flame, is

divided, for convenience of description, into three parts:

1st. That which surrounds the wick of oil, or candle, or jet of gas burner, the zone of *noncombustion*.

2d. The zone of *incomplete combustion*, where hydrogen mainly oxidizes, and where the particles of free carbon are brought to a high state of incandescence, by the heat developed by the burning hydrogen, radiate their light—the *luminous* portion of the flame—and

3d. The area of so-called *complete combustion*, where carbon, with any remaining hydrogen, is also oxidized.

Active chemical union between the burning gases and the supporting oxygen of the air, takes place mainly on the *surface* of the resulting flame, the interior being hollow; such physical condition is due to the fact that the oxygen of the air is exhausted at the immediate surface, and is therefore unable to penetrate the interior of the flame; but if the air (oxygen) be admitted to, and mixed with, the combustible gases, before ignition, as in the Bunsen burner, the extra oxygen, thus supplied, supports the simultaneous combustion throughout the flame, of both the carbon and hydrogen. Such

a flame is lacking in brilliancy, but possesses great heating power.

The same principles apply to the mouth blow-pipe flame. Air (oxygen), is blown by the cheeks, into the interior of the flame, which resolves the latter into two chief parts: a bluish inner cone and an outer cone. The outer cone is named the *oxidizing* area, because certain metals, when heated in it, become oxidized. The apex of the inner cone is possessed of great heating power, and is called the *reducing* portion of the flame, because certain metallic oxides, when heated at that point, are reduced to free metal and free oxygen. A little practice with the blow-pipe, under proper instructions, will enable the dental student to easily solder pieces of brass or copper, these metals being good substitutes for silver and gold in experimental practice.

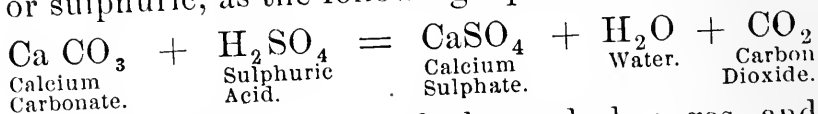
The heat of combustion, ordinary or special, is measured in heat units; one unit being the quantity of heat needed to raise one gram of water from 0° to 1° . Hydrogen burning in oxygen, furnishes 34,462 heat units, and carbon oxidizing, 8,080 units; that is to say, 1 grain of hydrogen, or of carbon respectively, in burning in oxygen, would raise the temperature of 34,462, or 8,080 grams of water from 0° to 1° .

CHAPTER XVI.

CARBON—*Continued.*

CARBON DIOXIDE.—Carbon and oxygen form two compounds, the monoxide (CO), and the dioxide (CO₂). The latter compound is also known as carbonic acid gas. It is a substance of frequent occurrence and wide distribution, being a product of ordinary combustion, and fermentation, and putrefaction of vegetable and animal tissues. From the bodies of living animals it is exhaled by means of the lungs, in respiration. It is usually set free, when carbonates are decomposed, and is the important constituent of the atmosphere, which supplies carbon to the vegetable kingdom.

Carbon dioxide is prepared for experimental purposes, or for producing, under pressure, the effervescence in *soda water*, by reaction between a carbonate and a dilute acid, usually hydrochloric or sulphuric, as the following equation will show :



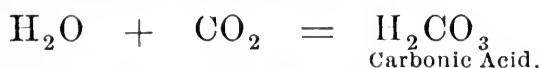
Carbon dioxide is a colorless, odorless gas, and possesses a slightly acid taste. It is one-and-a-half times as heavy as air, and twenty-two times

as heavy as hydrogen. It dissolves somewhat in water at the ordinary pressure and temperature of the air, but as the volume of a gas is inversely as the pressure, great quantities of CO_2 can be confined in water under pressure, as is seen in soda water, certain mineral waters, sparkling wines, and beer, which, on exposure to the air, rapidly lose their excess of CO_2 , and thereby soon become flat and insipid.

Carbon dioxide interferes with combustion by superseding the supporting oxygen, as is noticed in the action of the "Babcock Extinguisher."

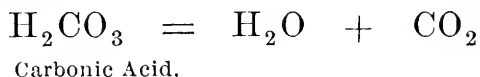
Animal respiration is also affected by the presence of an abnormal quantity of carbon dioxide, although it is not of itself a poison; it simply acts like water, or nitrogen, by preventing the due aeration of the blood; it often accumulates at the bottom of old wells, brewery vats, etc., and in such places its presence may be detected by lowering a lighted candle, which, if extinguished, will indicate an atmosphere dangerous to animal life. It is the *choke-damp* of the miners.

Carbonic acid is formed by the union of water and carbon dioxide under pressure.

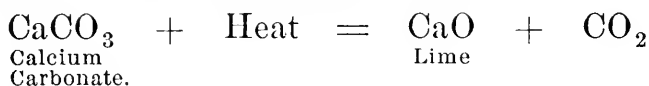


This acid does not exist as a commercial substance, like nitric, or other acids, because on re-

moval of pressure, it decomposes into water and carbon dioxide.



The salts of this acid, known as carbonates, are easily disrupted by heat, as well as by even, weak acids. Calcium carbonate, in the form of limestone, marble, chalk, oyster shells, etc., when heated, yield lime and carbon dioxide.



Carbon monoxide (CO), known also as *carbonyl*, and too frequently as carbonic oxide, is a combustible gas, odorless, colorless, and tasteless, and actively poisonous; one per cent in the atmosphere is considered dangerous. It may be prepared by various methods, but it is probably never produced synthetically. Some of the carbon dioxide formed during combustion, when arriving at the surface of the heated coal, suffers reduction ($\text{CO}_2 + \text{C} = 2\text{CO}$), at which point the resulting CO, meeting with atmospheric oxygen, unites with the latter, burning with a blue flame, and producing CO_2 . $\text{CO} + \text{O} = \text{CO}_2$.

Where the combustion is confined, as in certain anthracite stoves and furnaces, a portion of the CO may escape oxidation, and pass through the heated cast-iron to the surrounding air, causing serious annoyance to the occupants of the room.

Cigarette smokers are probably injured more by inhaling carbon monoxide (CO) than by any other cause connected with the habit. This gas is formed at the heated end of the burning cigarette, and which, when inhaled, enters the circulation and induces destructive chemical changes in the blood.

Carbon disulphide (CS_2) is formed synthetically by passing a stream of sulphur vapor over red-hot charcoal. The commercial carbon disulphide has an exceedingly nauseous odor, but, if pure, the odor is rather pleasant, suggestive of ether. It is a clear liquid, of specific gravity, 1.29. Its vapor mixed with air is explosive, and the compound itself is very combustible, yielding carbon dioxide and sulphur dioxide, $\text{CS}_2 + 6\text{O} = \text{CO}_2 + 2\text{SO}_2$.

Carbon disulphide owes its importance to its solvent properties. It easily dissolves such substances as caoutchouc, phosphorus, sulphur, oils, and fats, and is used largely for extracting oils from seeds and fats from animal refuse, and in the vulcanization of rubber.

With N, carbon forms one compound named cyanogen (CN), to be described under "ORGANIC CHEMISTRY."

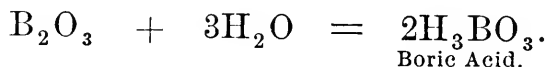
CHAPTER XVII.

BORON.

Symbol, B. Sp. gr. 2.68.

Boron is a constituent of many minerals. It may be obtained in two modifications. The first is a soft, dark brown powder, analogous to amorphous carbon, slightly soluble in water, and fusible in the oxy-hydrogen flame. The second variety is obtained in quadratic octahedral crystals, varying in color from yellow to garnet red; infusible, and nearly as hard and as highly refractive as the diamond.

Boric oxide, B_2O_3 , is formed whenever boron is burned in the air or oxygen. United with 3 molecules of water, it forms boric (ortho-boric) acid.



BORIC ACID.—Boric acid is usually obtained from solution of borax, in boiling water, by sulphuric acid. Occurs in white crystalline scales, soluble in water and alcohol, and possesses antiseptic properties.

Boron unites with H to form a gaseous com-

pound, BH_3 , resembling NH_3 and PH_3 . With F it forms a colorless gas, and with Cl a volatile liquid; but by far the most important compound of boron is *borax* ($\text{Na}_2\text{O} (\text{B}_2\text{O}_3)_2$), which will be considered in connection with sodium.

SILICON.

Symbol,	At. Wt.	Sp. Gr.
Si.	28.	2.49.

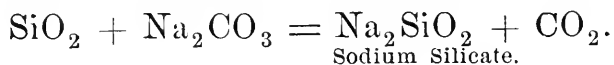
Inasmuch as we began the study of the non-metallic elements with oxygen, it is meet that we conclude the subject with the next most abundant ingredient of the earth's surface, namely, *silicon*, sometimes called *silicium*. It is obtained by heating together metallic potassium and potassium silicofluoride, $4\text{K} + \text{K}_2\text{SiF}_6 = 6\text{KF} + \text{Si}$.

Like carbon, silicon may be obtained in three different modifications. One is an amorphous dark brown powder. The second consists of hexagonal plates resembling graphite, and the third variety crystallizes in octohedrons of exceeding hardness. It fuses only at very high temperatures, and is insoluble in all acids, except hydrofluoric. The isolated element has no practical importance.

Silicon combined with oxygen, and also with potassium, aluminum, and other metals, enters largely into the structure of the solid crust of the earth.

The oxide of silicon (SiO_2), known as *silica*, and when in powder, as *silex*, is the principal earthy material of our planet, occurring more or less pure in sandstone, quartz, or rock crystal, amethyst, agate, cornelian, chalcedony, and the beautiful opal. In combination with certain metallic oxides, it forms a class of salts called *silicates*, of which by far the largest variety of minerals consist. Silicon oxide is found in animal tissues; it stiffens the stems of the various grasses and growing grains, and is also found dissolved in the waters of many thermal springs. It has a specific gravity of 2.6. The natural crystal is sufficiently hard to scratch glass; it is but slightly soluble in water, and is unaffected by acids, except hydrofluoric.

SiO_2 is an acid oxide. When sand is fused with sodium or potassium carbonate, a reaction ensues by which a *silicate* of these metals is formed.



The silicates of sodium and potassium are known as *water glass*. They are soluble in water, but the silicates of the other metals are in general, insoluble. Porcelain and glass are artificial mixtures of silicates. Porcelain (artificial) teeth, consist of aluminum silicate and the double silicate of aluminum and potassium. Window glass is a silicate of calcium and sodium. Bohemian glass is a sili-

cate of calcium and potassium. Crystal or flint glass, is a silicate of potassium and lead.

Silicon unites with hydrogen to form a colorless gas, SiH_4 , analogous to CH_4 . It unites with chlorine, bromine, and iodine, SiCl_4 , SiBr_4 , SiI_4 , corresponding to carbon chloride, bromide, and iodide. It also forms a chloroform, SiHCl_3 , similar in some respects to ordinary chloroform, CHCl_3 . Indeed, although silicon and carbon are apparently widely separated in nature, being the characteristic elements of the mineral and organic kingdoms respectively, they are very near akin in their chemical nature.

If a strong solution of sodium or potassium silicate be acted on by hydrochloric acid, a jelly-like substance will separate out. This substance is known as *ortho*-silicic acid, H_4SiO_4 . By losing a molecule of water it becomes *meta*-silicic acid, H_2SiO_3 . If the mixture of hydrochloric acid and water glass be sufficiently dilute, no separation of the silicic acid will take place. A separation, however, can be beautifully and instructively accomplished by *dialysis*. The *dializer*, consisting of a taut membrane of bladder or skin parchment, placed in the solution, whereby the sodium or potassium chloride will diffuse through the membrane, leaving a clear, tasteless solution of silicic acid,

which in time solidifies to a jelly. Crystallizable bodies like salt, sugar, etc., diffuse readily through the dializer, while non-crystallizable bodies, like jellies, glue, albumen, etc., do not pass at all. These two classes are termed respectively *crystalloids* and *colloids*.

PART SECOND.

INORGANIC CHEMISTRY.

CHAPTER I.

CHEMICAL PHILOSOPHY—*Resumed.*

Now that we are acquainted with some of the chemical and physical properties belonging to a few of the elementary forms of matter, we will be better enabled to understand more clearly the following additional facts in chemical philosophy.

The atomic theory of Dalton, which assumes that matter is made up of ultimate particles, called *atoms*, clearly explains the known laws of chemical reactions. As atoms are individually indivisible, *whole* atoms, or multiples of them, must be involved in chemical union. A chemical compound is definite in its nature, *i. e.*, each of its molecules, of which the mass is composed, must contain the same kind and number of atoms, similarly arranged.

We do not know the *real* weight of atoms, but as hydrogen is the lightest body, and therefore taken as unity, the *comparative* weights of the atoms of the several elements can be ascertained.

The real weights of the atoms of the several elements are fixed and unchangeable for each; it follows that molecules, each containing the same kind and number of atoms, producing a given compound, must be alike in weight. Equal weights of water, under equal conditions, will contain the same number of molecules; hence the molecular formula, $\overset{1}{\text{H}}_2\overset{16}{\text{O}}$, not only truly represents the relative quantities of H and O, but also the comparative weight of a given quantity of water. The molecular weight is the sum of the atomic weights. The molecular weight of water is therefore 18; that of $\overset{32}{\text{S}}\overset{16}{\text{O}}_2$ is 80; these two substances combine with each other in the above proportions to form a molecule of H_2SO_4 , whose weight is the sum of $18 + 80 = 98$.

Aside from the known relative weights, or multiples of them, in which the elements unite with or displace each other, there are other relations between the accepted atomic weights, and certain physical phenomena, which prove the correctness of the former.

The remarkable relation between the atomic weights of the elements, and their capacity for heat, called specific heat, or atomic heat, is expressed by the statement that *the products of the specific heats of the elements into their atomic weights,*

give a nearly constant quantity, the mean value being 6.4. The slight variations noticed are no doubt due to unavoidable errors in experiment. In other words, all *atoms* have equal capacities for heat; the same amount of heat that will raise 1 part by weight of hydrogen one degree, will raise 7 parts by weight of lithium, 16 of oxygen, 23 of sodium, 56 of iron, 108 of silver, 197 of gold, etc., one degree.

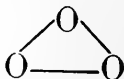
In many cases, the molecules of compounds which crystallize in like form, called *isomorphous*, are supposed to contain an equal number of atoms; thus, certain sulphates are isomorphous with corresponding selenates; sesquioxide of iron, Fe_2O_3 , is isomorphous with sesquioxide of aluminum, Al_2O_3 ; and in case of doubt as to the correct atomic weight of an element, as for instance of aluminum, this relation is appealed to.

All molecules, according to the law of Ampere, have the same size; that is, all molecules, when in the gaseous state, under equal conditions of heat and pressure, occupy the same volume, or same amount of space. The composition of gaseous elementary molecules can therefore be expressed in volumes, as well as in atoms. The molecule of hydrogen is assumed to contain 2 volumes, or 2 atoms, of hydrogen, IIII; the *molecular* weight of

hydrogen is therefore 2, twice that of a single atom of hydrogen; and as this element is taken as unity, its *density* is one-half its molecular weight, or its *molecular* volume is equal to 2 *atomic* volumes. Those elementary gases or vapors whose molecules are supposed to contain 2 volumes, or 2 atoms, have a density, referred to hydrogen as unity, equal to one-half their molecular weights, or identical with their atomic weights.

DENSITY.		DENSITY.	
Hydrogen.....	1	Sulphur.....	32
Oxygen	16	Bromine	80
Chlorine.....	35.5	Iodine.....	127

Since the molecular weight represents the weight of two volumes, as H_2 , $\text{O}=\text{O}$, and density represents the weight of one volume, the density of any homogeneous vapor, either elementary or compound, is one-half its molecular weight.

Ordinary oxygen, whose molecular formula is $\text{O}=\text{O}$, has a molecular weight of $16 + 16 = 32$; its density is one-half of 32, or 16. Ozone, ,

has a molecular weight of 48; its density is 24. Carbon dioxide, whose formula is CO_2 , has a molecular weight of $12 + 32$, or 44; its density is $44 \div 2$, or 22. Conversely by knowing the density, the molecular weight can be obtained by multiplying by 2.

It is also noticed that the gaseous product of the union of two elementary gases, when combining in equal volumes, retains the original volume of its constituents; as 1 vol. of H and 1 vol. of Cl form 2 vols. of HCl. When 3 or more vols. of combining gases, elementary or compound, enter into combination, condensation takes place to 2 volumes, as

2 vols. of H and 1 vol. of O form 2 vols. H_2O ;

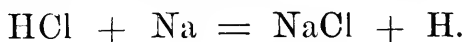
1 vol. of ethyl CH_5 and 1 vol. of Cl form 2 vols. CH_5Cl ;

2 vols. of ethyl $(\text{CH}_5)_2$ and 1 vol. of O form 2 vols. $(\text{CH}_5)_2\text{O}$.

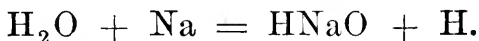
Hence the law of Avogadro: *The molecules of all gases, simple or compound, occupy equal volumes; or equal volumes of all gases contain equal numbers of molecules.* The molecular formula of compound gases (or vapors), and the atomic weights of the elements contained in them, can, by noting the vapor density, be determined by this law.

EQUIVALENCY.—Certain elements unite with each other in only one proportion; they form, with each other, but one compound. Their atoms have only one point of attraction; their atomicity or *valency* is *one*. These elements are called *monogenic* or *monads*, signifying one. The other elements are called *polygenic*. The atoms of the monad ele-

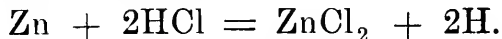
ments are equivalent to each other; the atoms of the polygenic elements are equal in combining, or substituting power, to two or more atoms of the monads. One atom or volume of H, and one atom or volume of Cl unite; they form but one compound, HCl; they are both monads. One atom of Na will displace H and take up with the Cl:



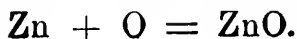
The valency of Na is, therefore, the same as H and Cl; it is monogenic. The atom of O, however, is equal in combining power to two atoms of H, Na, or any other monad; oxygen, therefore, is a *dyad* element. One atom of O and two atoms of H unite (H_2O). One atom of Na will drive out one atom of the hydrogen and take its place; the one atom of oxygen being able to attract and hold together the two unlike atoms in a homogeneous molecule:



One atom of Zn (65 parts by weight) requires two molecules (73 parts by weight) of HCl to satisfy its combining power:



Zinc, accordingly, is a dyad. When zinc is oxidized, the molecule produced contains one atom each of dyad zinc and dyad oxygen:



This difference in the number of points of attraction or saturating power belonging to each atom of the various elements is often denoted by placing Roman numerals, or dashes above or to the right of the symbols, as—

Univalent elements, or monads, as.....Hⁱ

Bivalent elements, or dyads, as.. ..Oⁱⁱ

Trivalent elements, or triads, as.....Auⁱⁱⁱ

Quadrivalent elements, or tetrads, as...C^{iv}

Quinivalent elements, or pentads, as..P^v

Sexvalent elements, or hexads, as.....Cr^{vj}

Elements of even equivalency, namely, the dyads, tetrads, and hexads, are classed under the general term *artiads*, signifying *even*; and those of uneven equivalency, the monads, triads, and pentads, are called *perissads*, which means *uneven*.

CHAPTER II.

GRAPHIC FORMULA.

Formulæ are sometimes written *graphically*, that is, a number of lines or bonds, connecting the symbols, indicating the equivalency of each; thus:

Hydrochloric acid, HCl $\text{H}-\text{Cl}$

Water, H_2O $\text{H}-\text{O}-\text{H}$

Carbon dioxide, CO_2 $\text{O}-\text{C}-\text{O}$

Am. Chloride, NH_4Cl $\begin{array}{c} \text{Cl} \\ | \\ \text{H} > \text{N} < \text{H} \\ | \\ \text{H} \end{array}$

Nitric Acid, HNO_3 $\begin{array}{c} \text{O} \\ || \\ \text{N}-\text{O}-\text{H} \\ || \\ \text{O} \end{array}$

Zinc Nitrate, $\text{Zn}(\text{NO}_3)_2$ $\begin{array}{c} \text{O} \\ || \\ \text{N}-\text{O}-\text{Zn}-\text{O}-\text{N} \\ || \qquad \qquad || \\ \text{O} \qquad \qquad \text{O} \end{array}$

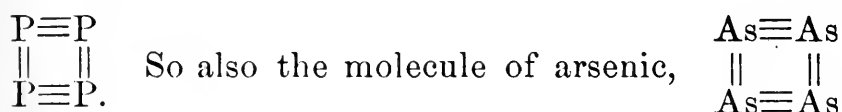
These graphic formulæ are often abridged by the use of dots only, thus:



By observing the above diagrams, it will be noticed that the units of attraction belonging to each atom are satisfied by union with those of other

atoms. And, accordingly, it is found that in all saturated molecules, *the sum of the perissad atoms is always even*. A molecule may contain 2, 4, or 6, etc., monad atoms, as in HCl, H₂O, CH₄, C₂H₆, etc.; or 1 triad atom, as Auⁱⁱⁱ, and 3 monads, as in AuCl₃; or 1 pentad and 5 monads, as in NH₄Cl; but never an uneven number of perissad atoms. This is the law of *even numbers*.

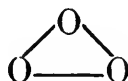
For the same reason the molecules of the perissad elements consist of an even number of atoms. The molecule of hydrogen contains *two* atoms H—H. So also the molecule of chlorine Cl—Cl; the molecule of phosphorus contains *four* atoms,



The molecules of dyad elements, however, may contain either an even or an uneven number of atoms, as will be observed on again submitting the following:



Ordinary oxygen.



Ozone.

The true equivalency of an element may be expressed as *that which represents the maximum number of monads atoms, with which one atom of it can combine*. The molecule, ammonium chloride, NH₄Cl, shows one atom of N saturated by *five* monad

atoms; no other atom or atoms can unite with the above group. Accordingly nitrogen is a pentad, *i. e.*, its atom is equal to five monad atoms. One atom of dyad oxygen can take up with no more than two atoms of monad hydrogen $\text{H}_2\text{O}^{\text{ii}}$.

When variation in the valency of any element occurs, it always takes place by 2 units. So that an element may appear as a *monad* in one compound, a *triad* in another, and a *pentad* in still another; or an element may act as a *dyad* in one case, or a *tetrad* in another, and a *hexad* in another. For instance, nitrogen appears to be a monad in nitrous oxide N_2O , a triad in ammonia NH_3 , and a pentad in ammonium chloride NH_4Cl ; sulphur is a dyad in dihydrogen sulphide H_2S , a tetrad in sulphurous oxide SO_2 , and a hexad in sulphuric oxide SO_3 .

In compounds where the full valency of the element is not exhibited, as in NH_3 , ammonia, the two units belonging to N uncombined, probably unite with each other, for the time being; but the molecule of ammonia is willing to unite directly with HCl , forming NH_4Cl , wherein the full valency of N^{v} is satisfied. Tetrad sulphur in SO_2 can be oxidized into SO_3 , becoming thereby a hexad.

A perissad element is always a perissad; an artiad element, always an artiad, inasmuch as vari-

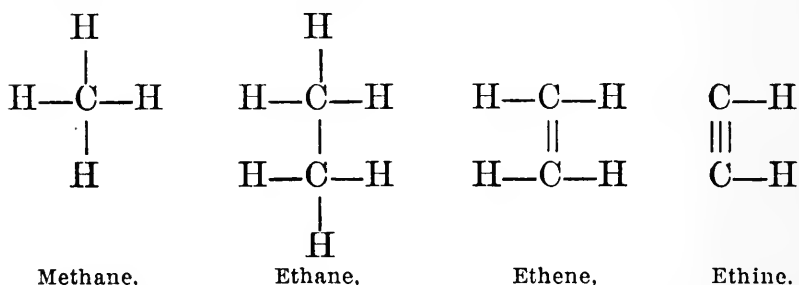
ation in valency of either class, when it does occur, is always by 2 units.

The statement that the true valency of an element is determined by the composition of its hydrides, chlorides, etc., rather than by its oxides, etc., will be appreciated if we consider the part dyad atoms play in combination. For example, dyad O^{ii} can enter the saturated molecule of water $H-O-H$ without disturbing the existing atomic value of hydrogen, thus $H-O-O-H$, because any dyad atom (or radical), introduces one unit of equivalency into the compound which it enters, and neutralizes another, leaving the valencies the same as before. Potassium is a monad, because one atom of it unites with only one atom of chlorine, $K-Cl$, and in no other proportion; but in addition to its corresponding oxide, $K-O-K$, there is a tetroxide of potassium $K-O-O-O-O-K$, wherein the valency of the K^i is seen to be the same as in its normal oxide. Any other dyad atom (or radical) can act in the same way.

When two or more atoms of a polygenic element are present in the same molecule, the element in question may seem to possess less than its normal valency. Carbon is a tetrad inasmuch as four atoms of hydrogen or other monad, are as many as one atom of carbon can saturate, (CH_4); there are,

however, a great many other compounds of C and H alone, whose molecules contain more than one atom of carbon, and where the C appears to possess an atomicity of less than four. This is owing to the units of valency, belonging to the carbon atoms, not saturated by the hydrogen (or in other cases by atoms of other elements), uniting with, and so satisfying each other. One or two examples will suffice:

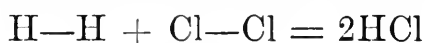
In methane, CH_4 , carbon is a tetrad; in ethane, C_2H_6 , carbon appears to be triad; in ethene, C_2H_4 , it appears to be a dyad, and in ethine, C_2H_2 , a monad. The following diagrams will readily explain the apparent discrepancy:



The same faculty, of mutual combination of otherwise free units, is possessed by the atoms of other polygenic elements, but not in as high a degree as with those of carbon.

RADICALS.—Radicals may be defined as residues, obtained by removal of one atom or more from a saturated molecule. There are elementary and

also compound radicals. A perissad atom, as an atom of hydrogen, H, is an elementary radical, and probably never exists free; such atoms, when set free from combination, unite either with each other or with atoms of another kind to form again saturated molecules. A mass of hydrogen, for instance, does not consist of an aggregation of uncombined atoms, H, H, H, H, H, but of a great number of molecules, each containing two atoms, chemically united, H—H. Suppose a molecule of hydrogen, H—H, be acted on by a molecule of chlorine, Cl—Cl, the reaction would be as follows:



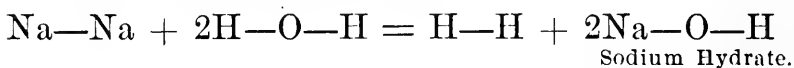
The two atoms (radicals) of the hydrogen molecule, and the two atoms (radicals) of the chlorine molecule, would become separated by the influence of the superior chemical attraction between the unlike atoms (radicals), and recombination take place, resulting in the production of two molecules of hydrogen chloride, as seen in the equation.

Again suppose, these latter two molecules, 2HCl, be brought under the influence of a molecule of sodium (Na—Na), another change would occur, $2\text{HCl} + \text{Na—Na} = 2\text{NaCl} + \text{H—H}$. The 2Cl radicals would leave the hydrogen and take up with the 2 Na atoms (radicals), forming 2 molecules of sodium chloride, letting the 2H atoms go free,

which, in the absence of more attractive radicals of some other kind of matter, would be satisfied to unite with each other, and give birth again to a molecule of hydrogen.

Compound radicals are unsatisfied groups of two or more unlike atoms, and have a valency corresponding to the number of equivalent units removed from a saturated molecule. H—O—H (water), is a saturated molecule; if one of the hydrogen atoms be removed, the resulting group, —O—H (hydroxyl), will evidently have the same combining power as the divorced atom of hydrogen (H—). Hydroxyl is, therefore, a univalent (monad) compound radical, having one free bond. It exists in all the *hydrates* and in many other compounds.

Sodium thrown on water removes an equivalent quantity of hydrogen, and takes its place, in union with the resulting hydroxyl:



The names of compound radicals of uneven valency (monads, triads, etc.) end in *yl*; they do not exist free, but the instant of their development, if unaffected by radicals of another kind, they tend, like perissad atoms, to combine among themselves. Free hydroxyl is not known, but a compound whose molecules are made up of 2 hydroxyl groups, H—O—O—H , is a well known substance.

Compounds in general are often formulated so as to show their molecular constitution by radicals. Thus, nitric acid, HNO_3 , may be considered as con-

sisting of the 2 radicals, $\text{H}-\text{O}-$ and $\begin{array}{c} \text{O} \\ || \\ \text{N} \\ || \\ \text{O} \end{array} = \text{HO}.\text{NO}_2$.

Water is analogous in formula to sodium hydrate, H.OH Na.OH . The graphic formula of phosphoric
Water. Sodium hydrate.

acid is $\begin{array}{c} \text{O}-\text{H} \\ | \\ \text{O} = \text{P} - \text{O}-\text{H} \\ \quad \quad \quad \diagdown \\ \quad \quad \quad \text{O}-\text{H}, \text{ etc.} \end{array}$

An understanding of the part played by radicals in the carbon compounds included in organic chemistry, is most important, and their relations may be somewhat studied in this connection to advantage.

The atom of carbon has four points of attraction ; it can not, therefore, take up more than four atoms of hydrogen, or other monad radical. Methane, $\text{C}^{\text{iv}}\text{H}_4$, is the typical saturated hydro-carbon. If one of the four atoms of hydrogen be removed, the residue will, of course, be $\text{C}^{\text{iv}}\text{H}'_3$, named *methyl*, which has the same valency as the atom of hydrogen, or *one unit*, capable of uniting with one atom of chlorine, for instance, to form methyl chloride, $\text{CH}'_3\text{Cl}$. Two atoms of hydrogen removed from

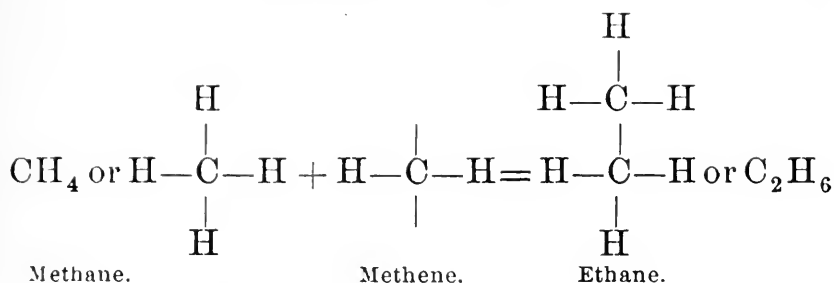
methane, CH_4 , leaves the dyad radical methene, CH''_2 , able to take up two atoms of chlorine to form methene chloride, $\text{CH}''_2\text{Cl}_2$. Three atoms of hydrogen removed from methane, results in the trivalent radical methenyl, CH''' , which in union with three atoms of chlorine, produces methenyl chloride, CHCl_3 (chloroform), and if all four of the hydrogen atoms in methane be driven out, the tetrad carbon atom remains to be saturated by four atoms of chlorine, CCl_4 , or other monad element, or by two dyad radicals, or by one triad and one

monad radical, $\begin{array}{c} | \\ -\text{C}- \\ | \end{array}$.

Allusion has been made to the non-interference of dyad atoms, or radicals, with the equivalent values of the atoms or radicals, in those saturated molecules which they may enter.

The dyad compound radical, methene, $\begin{array}{c} \text{H} \\ | \\ -\text{C}- \\ | \\ \text{H} \end{array}$

like an atom of oxygen $-\text{O}-$, can evidently join itself to an already satisfied molecule, because it is able to neutralize one unit of valency in the compound it enters, and introduce another, as may be understood by the following diagram :



Ethane, C_2H_6 , is methane CH_4 , plus the dyad radical CH_2 . If we presume to abstract one atom of hydrogen from ethane, we will have the univalent radical *ethyl* $\text{C}_2\text{H}'_5$, capable of joining itself to an atom of chlorine, as in ethyl chloride $\text{C}_2\text{H}'_5\text{Cl}$, or to hydroxyl, as in alcohol, $\text{C}_2\text{H}'_5\text{OH}$, or two such groups, to —O— , as in common ether $(\text{CH}_5)_2\text{O}$.

Hydrogen is not the only element involved in removal from saturated molecules, to form radicals. Indeed it is only necessary to assume a number of units of valency abstracted from any saturated molecule, in order to obtain a radical of corresponding combining power; and it is evident, from their mode of derivation, that the number of compound radicals which are capable of existence is without limit. A great many of them are known to individually enter into the formation of special classes of compounds, like the salts of the same metal, enabling us to comprehend clearly the relations that exist between vast numbers of organic compounds, which otherwise would be impossible.

CHAPTER III.

MATERIA MEDICA.

Materia Medica is that part of therapeutics which includes the study of the origin, physical and chemical nature, therapeutic and toxic effects, local and general, of *materials* employed for the cure, alleviation, or prevention of disease.

Although it is not often incumbent on the dentist to prescribe medicines for internal administration, it is proper that he should know the general effects, dosage, incompatibles and antidotes, when so exhibited, of those drugs he uses in his practice as local agents, inasmuch as a large majority of them are active poisons.

By knowing these facts he can make judicious selection and combination of materials for any prescription that, in his judgment, will best suit the case in hand. He would not, for instance, order a combination of any soluble chloride with silver nitrate, or any vegetable astringent, with persalts of iron; or use, even topically, excessive quantities of *arsenic*, or tincture of aconite root, etc.

The art of writing decent prescriptions is a serious labor to the average student. If we could pre-

vail upon him to discard in toto the signs and symbols of the old system of weights and measures and adopt the metric system exclusively, he would find the task much easier; and if, as occasionally happens, he be deficient in a knowledge of the Latin language, he should take courage, and realize that very few Latin phrases, or abbreviations, are needed in prescribing, as the following sufficient presentment of them will prove:

A; aa, *Ana*; of each.

Ad. add., *Addendus*; to be added.

Ad lib., *Ad libitum*; at pleasure.

Alb., *Albus*; white.

Aq., *Aqua*; water.

Aq. dest., *Aqua destillata*; distilled water.

Chart., *Charta*; paper.

Dil., *Dilutus*; diluted.

F., *Ft.*, *Fiat*; let a — be made.

Fl., *Fluidus*; liquid.

Fol., *Folium*; a leaf, *Folia*; leaves.

Gr., *Granum*; a grain. *Grana*; grains.

Gtt., *Gutta*; a drop: *Guttæ*; drops.

Hyd., *Hydro*; water.

Hydr., *Hydrargyrum*; mercury.

Inf., *Infusum*; infusion.

M., *Misce*; mix.

Mist., *Mistura*; a mixture.

No., Numero; in number.

Ol., Oleum; oil.

P., Pulvis; powder.

Ph., Pharmacopœia.

Pil., Pilula; a pill; pilulæ, pills.

Q. S., Quantum Sufficiat; as much as is sufficient.

R., Recipe; take.

Rad., Radix; root.

Rect., Rectificatus; rectified.

S., or Sig., Signa; write.

Ss., Semis; half.

Solv., Solve; dissolved.

Spr., Spiritus; spirit.

Tr., or Tinct., Tinctura; tincture.

U. S. P., United States Pharmacopœia.

In writing a prescription containing a number of substances, it is proper to place the most important article in the combination, first, as the *basis*; the *adjuvans* or *assistant* to the base, next; the *corrective*, if the two first have certain objectionable properties, as taste or smell, comes next; and finally the *vehicle*, to give form and elegance to the whole. The following will serve as an example:

R.	Acidi salicylici.	<i>Basis.</i>
	Sodii biboras, aa 1.00 Gm. (gr. xv),	<i>Assistant.</i>
	Spts. rect., 4.00 CC. (f ʒ i),	<i>Corrective.</i>
	Aq. rosæ q. s. ad 125.00 CC (f ʒ iv),	<i>Vehicle.</i>

M. S. Use as a general mouth wash.

Apothecaries' weights and measures.

Pound.		Ounces.		Drachms.		Grains.
Lb. 1	=	12	=	96		5760
		3i	=	8	=	480
				3i	=	60

Fluid measure.

Pint (Octarius).		F, Ounces.		F, Drachms.		Minims.
Ol	=	16	=	128	=	7680
		f 3i	=	8	=	480
				f 3i	=	m 60

METRIC SYSTEM.

The *meter* is the basis of the metric system, and is the standard unit of *linear measurement* of that system.

The meter is the 10 millionth part of the distance from the equator to the pole (the earth's quadrant); it is about 10 per cent longer than the *yard*.

The unit of fluid measure is the *liter*—the cube of $\frac{1}{10}$ meter (one decimeter), or 1,000 cubic centimeters; it is equal to about 32 fluid ounces.

The *cubic centimeter* (C.C.) is equal to about 15 minims.*

* Exactly 16.231 minims. Approximative comparison is sufficient for our purpose.

The *Gram* is the metric unit of *weight*, and represents the weight of 1 cubic centimeter of water at its maximum density (4° C—39° F). The *gram* is equal to about 15 grains. Fractions over 15 grains and 15 minims, with reference to the gram, and to the cubic centimeter, may be ignored.

We accordingly have:

1 Gram equal to 15 grains.

4 Grams equal to 1 drachm.

1 Drachm equal to 4 Grams.

1 Cubic centimeter equal to 15 minims.

4 Cubic centimeters equal to 1 fluidrachm.

1 Fluidrachm equal to 4 cubic centimeters.*

The term *fluigram* has been suggested as more euphonious than *cubic centimeter*, but has not been generally accepted. Inasmuch, however, as the gram expresses the weight of 1 cubic centimeter of water, the term fluigram is not inappropriate, and will be used by us hereafter instead of cubic centimeter: fluigram abbreviated f. Gm, and Cubic centimeter CC, mean, therefore, the same measure of any liquid.

Gram should be written with a capital "G," abbreviated Gm; and in order to avoid mistaking this sign for gr, which latter is always written with a small "g," it is proper to place the Arabic

* Slightly changed from Oldberg.

numerals *before* the sign; thus, 10.00 Gm (ten Grams). Apothecaries' weights and measures (old system) have their signs *followed* by Roman numerals, thus, gr x (ten grains).

In *writing* prescriptions according to the metric system, the only signs needed are the Gm and fGm; and fractions of them are stated decimally, in the same way we write our divisions of federal money, thus:

10.00 Gm (ten grams), analogous to \$10.00 (ten dollars); 0.05 Gm (five centigrams), analogous to \$0.05 (five cents).

If we regard the Gm or fGm, as corresponding in this respect to our dollar, we can appreciate the relation most easily by the following comparison:

Gm	\$
1.00—One Gram.	1.00—One dollar.
.50—Fifty centigrams.	.50—Fifty cents.
.02—Two “	.02—Two “
.001—One milligram.	.001—One mill.

In *speaking* of the divisions of the gram, the same terms may be employed that are used in *speaking* of money matters. For instance, 0.10 Gm = one dime; or 0.10 fGm = one fluidime. The *fluidime* may be considered the minimum quantity for liquids, equal to $1\frac{1}{2}$ minims, and the *mill*, the

smallest representative of weight, equal to $\frac{1}{64}$ of a grain.

The prefixes used in the metric system are sometimes convenient in *speaking* of weights and measures, but in prescribing they need not be *written*, the Arabic numerals being sufficiently explicit. As, for instance, with reference to any unit in the metric system.

Myria means.....	10.000
Kilo “	1.000
Hecto “	100
Deka “	10
Deci “	0.1
Centi “	0.01
Milli “	0.001

The following approximate equivalents are mainly taken from Oldberg, and are sufficiently accurate to answer all purposes of mere comparison :

Troy Grains (or Minims).	Grams (or Fluigrams).
$\frac{1}{64}$	0.001 (1 mill)
$\frac{1}{2}$	0.03 (3 cents)
1	0.06 (6 cents)
$1\frac{1}{2}$	0.10 (10 cents)
10.....	0.65 (65 cents)
15.....	1.00 (1 Gram), (or fGm)
30.....	2.00 (2 Grams), (or fGm)
60 (1 Drachm) (Fl drachm))..	4.00 (4 Grams), (or fGm)

Troy Ounces (or Fluid Ounces).	Grams (or Fluigrams).
1	30.00 (30 Gm or fGm)
4	120.00 (120 Gm or fGm)

With the foregoing preliminaries in materia medica, more or less mastered, our hope is now to study carefully the medicinal properties, in connection with the chemical history of the various metallic salts, and organic compounds, that may be deemed worthy of notice.

We shall endeavor to systematize the study, by first presenting their physiological and therapeutic effects, if any, when applied *locally*; then, when taken internally, their influence on the brain and nervous system generally; on the circulation, respiration, temperature, and on the secretions; naming the principal diseased conditions in which they are indicated; and, finally, their antidotes and dosage, with an occasional prescription.

CHAPTER IV.

METALLIC ELEMENTS.

All those elements, studied in Part First, with the exception of hydrogen, are classed as non-metallic; those elements yet to be considered, with the exception of arsenic, are classed as metallic. Arsenic seems to be the connecting link between the two classes.

A few of the metals, as gold and platinum, are found in nature, in the metallic state; the large majority, however, are found united with non-metallic elements, forming oxides, chlorides, carbonates, etc., wherein the metallic properties are masked, and which constitute the *ores* from which the metals involved, are obtained.

Some of these elements, as gold, iron, copper, etc., are most useful when in the metallic state; and others, as potassium, calcium, barium, etc., are most important when in combination with non-metallic elements.

When metals unite with non-metals, true chemical compounds are formed. When metals unite among themselves (except with arsenic, and those closely allied to it), the combination does not

produce a true chemical compound, but an *alloy*, wherein the metallic nature is preserved. Many alloys are extremely useful, and exhibit desirable properties not possessed by their individual constituents; gold is too soft for ordinary use, but if alloyed with copper, or silver, or platinum, etc., becomes qualified for certain practical purposes. Copper is too soft and tough to work in a lathe, but if fused with one-half its weight of zinc, it forms the hard, tenacious alloy, known as brass. Copper and tin in different relative proportions give us the useful alloys, bronze, bell metal, speculum metal, etc. German silver consists of 100 parts copper, 40 of nickel, and 16 of zinc. Type metal is an alloy of antimony and lead. Alloys of mercury with other metals are named *amalgams*.

The melting point of an alloy is generally lower than the mean melting point of its constituents. For instance, tin melts at 235° (455° F.); bismuth, melts at 264° (507° F.); lead melts at 320° (608° F.).

An alloy of 1 part of tin, 2 of lead, and 2 of bismuth will melt as low as 93° C (200° F.). Such an alloy is useful in attaching teeth, by dovetail, to old celluloid and rubber plates, and may be packed in with a warm burnisher.

The metals differ greatly in *specific gravity*, ranging from potassium, sodium and lithium, which are

lighter than water, to platinum, iridium and osmium, which are more than 21 times heavier than water.

They differ also in *tenacity*, or the power of resisting tension. The order of tenacity among those metals susceptible of being easily drawn into wire is determined by observing the weights required to break wires of the same size, and is as follows: Iron, copper, platinum, silver, gold, zinc, tin, and lead.

Malleability, or power of extension under the hammer, or between the rollers of a flatting mill, is possessed in a high degree by gold, silver, copper, tin, platinum, lead, and iron.

The *fusing* points of metals vary greatly, ranging from mercury, which melts at -39° , to platinum, which requires the heat of the oxy-hydrogen flame. A certain uniformity of *color* is presented by the metals, except copper, which is red, and gold, which is yellow; all the other metals (leaving out the faintly pinkish tint of bismuth, and the yellowish tinge of calcium and strontium), are included between the white of silver and the bluish gray of lead.

The several metals are classified into groups, according to certain chemical and physical properties possessed by them; those of the same group

generally, also, possess the same valency. Brief allusion to some of the characteristics of two or three groups will suffice. For example:

The *metals of the alkalis*, viz., K, Na, Rb, Cs, and Li, are soft, easily melted, volatile at a higher temperature, will decompose hot or cold water through their love for oxygen. Their oxides are strongly basic, and are very soluble in water, forming exceedingly caustic and alkaline hydroxides. Their carbonates are soluble in water, and being *monads*, they each form only one chloride (K Cl).

The *metals of the alkaline earths*, Ca, Ba, and Sr, form oxides less soluble in water than those of the preceding group, but exhibiting, though in less degree, similar basic, caustic and alkaline properties. Their carbonates are insoluble in water; they each form but one chloride, which, as they are *dyads*, is a dichloride (CaCl_2).

The *metals of the earths*, erbium, yttrium, didymium, etc., form oxides that are not soluble in water. The metals of this group occur only in a few rare minerals.

All metals form binary compounds with chlorine. The monochlorides and dichlorides of the metals, excepting silver chloride (AgCl), and mercurous chloride (Hg_2Cl_2), are soluble in water. Metallic chlorides unite with certain oxides, form-

ing *oxychlorides*, and with organic bases, also, such as aniline and the ptomaines.

Nearly all metals unite with Br and I. Most metallic bromides and iodides are soluble in water; they closely resemble, in many instances, the corresponding chlorides.

Oxygen unites with all the metals, with many of them in several proportions. Some metallic oxides, as K_2O and CaO , do not decompose by heat alone; others, as Au_2O_3 , Ag_2O , PtO_2 and HgO , lose their oxygen by a low red heat. Most of them suffer reduction by hydrogen, aided by a more or less high temperature, while *carbon*, at a red or white heat, completely reduces all to the metallic state.

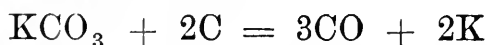
CHAPTER V.

POTASSIUM.

Symbol,	At. Wt.	Sp. Gr.	Valency,
K.	(Approx.)	0.87.50.	I.
	39.		

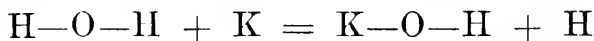
POTASSIUM occurs abundantly in nature, always however in combination. It is an essential constituent of animal and land vegetable bodies, and is found largely in many minerals. The ashes of land plants, are especially rich in potassium, hence its name.

Potassium was discovered by Davy in 1807 by electrolysis; it is now obtained by heating the carbonate with charcoal, *e. g.*



The metal, being volatile, distills over, is passed through naphtha, and condensed to proper form. It melts at 62.5° (144.5°F); it is soft at common temperatures, and can be easily cut with a knife, presenting a brilliant white surface, which soon tarnishes, owing to the strong liking it has for oxygen. For this reason, it soon loses its identity when exposed to the air, and must be preserved in some liquid, destitute of oxygen, such as naphtha.

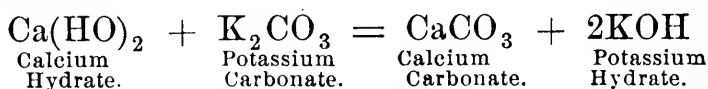
Thrown on water, it floats; at the same time causing equivalent decomposition of that liquid.



So great is the chemical energy of this reaction, that the hydrogen as it escapes from the water, is set on fire.

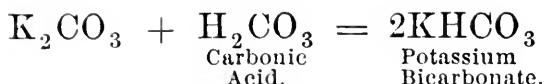
Potassium forms several oxides; the *normal oxide*, K_2O , being obtained by direct oxidation, or by action of potassium on the hydrate.

Potassium Hydrate (hydroxide) KOH , commonly called caustic potash, is generally prepared by action of calcium hydrate (milk of lime) on potassium carbonate.



Potassium hydrate is a white, soluble, deliquescent solid; strongly alkaline, caustic and poisonous.

Potassium carbonate, K_2CO_3 , is the familiar substance, potash. It is prepared from wood ashes, and by various other chemical processes; when refined it is known as pearlash; it has a strong alkaline reaction, is soluble in water, but insoluble in alcohol; is used in preparing other potassium compounds, and for the making of glass and soft soap. By treatment with carbonic acid it produces the "bicarbonate."



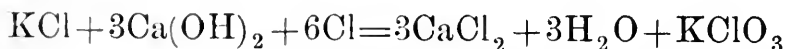
The bicarbonate is also called the hydrogen carbonate, and *acid* carbonate, although it is mildly alkaline.

Potassium chloride, KCl, obtained principally from sea water, is a colorless solid, soluble in water, and is found in the juices of animal bodies.

Potassium Iodide, KI, is prepared by the action of iodine on potassium hydrate. It occurs in colorless cubical crystals, of sp. gr. 3, soluble in water and alcohol.

Potassium Bromide, KBr, is similar in appearance to the iodide, and is obtained by an analogous process.

Potassium Chlorate, KClO₃, is prepared by passing *chlorine* through a solution of the carbonate; or through a solution of the chloride, containing milk of lime.

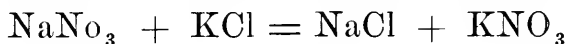


It is a colorless crystalline anhydrous solid, soluble in 20 parts of cold water. When heated it gives up all of its oxygen, and when mixed with combustible matter, like sulphur, tannin, etc., it becomes explosive. With phosphorus it is largely employed in the making of instantaneous-light matches.

Potassium nitrate, KNO_3 , commonly known as saltpeter and niter, occurs naturally in the soil, from oxidation of ammonia in the presence of potassium compounds.

Potassium nitrate crystallizes in anhydrous six-sided prisms, soluble in 7 parts of water.

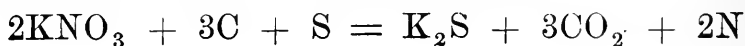
It is prepared in large quantity by reaction between *Chili* saltpeter and crude potassium chloride.



When heated in the presence of combustibles, it gives up its oxygen; hence it is used in the manufacture of gunpowder and in nearly all pyrotechnic compositions, which accordingly burn independently of atmospheric oxygen. Average gunpowder is a mechanical mixture of niter, charcoal and sulphur, in the following proportions:

KNO_3	75
C	15
S	10
	<hr/>
	100

The force of the explosion of gunpowder is due to sudden formation of gases and their immediate expansion by the heat. All of the powder is at once vaporized, and although the chemical reaction is really complicated, it may be approximately represented by the following equation:



Potassium Permanganate, $K_2Mn_2O_8$, is prepared from mixed aqueous solutions of potassium chlorate and manganese dioxide, by evaporating to dryness, and gently heating. It occurs in dark purple crystals, of a pleasant, astringent taste; dissolves easily in water, conferring a deep lilac color, which may be decolorized by Fowler's solution.

It is a powerful oxidizing agent, used in chemical analysis, and for destroying putrid matter.

Potassium forms a great many other compounds, such as the perchlorate, bromate, iodate, sulphide and sulphate, phosphates, borates, silicates, etc., their consideration, however, in this connection is unnecessary.

MATERIA MEDICA.—Some of the potassium salts produce active *local* effects. The *hydroxide* is one of the most penetrating caustics, owing to its removal of water from the tissues, and saponifying the fats.

The disadvantage of its penetrating qualities, is somewhat overcome by combination with lime; its use as a free caustic has been practically abandoned.

The *permanganate*, on account of its giving up active oxygen to organic matter, is an excellent disinfectant in fetid odors and as a gargle in gan-

grenous conditions of the mouth and throat.
Dose, 0.06 Gm. (gr.j).

The *nitrate* and *chlorate* are employed in solution, or powder, on inflammatory mucous membrane of the mouth and throat. The latter drug especially is effective in mercurial stomatitis.

When taken internally the potassium salts, as a rule, weaken the normal functions of the brain, including the co-ordination of motion, reduce the reflex sensibility of the spinal cord and nervous system generally. They also cause a lowering of the heart's action, of respiratory movement and of temperature. The secretion of saliva is lessened, and of the gastric juice increased. It may be well to mention here that *alkalies*, in moderate doses, decrease the secreting power of those glands which normally secrete an alkaline fluid, like the parotid glands, and increase the power of glands which secrete an acid, like those of the stomach. *Acids* have precisely the opposite effect.

Most of the salts of potassium are diuretic and slightly purgative.

The *chlorate*, in doses of 0.50 Gm. (gr.viii) is indicated in mercurial salivation, aphtha, and ordinary tonsillar inflammation, suggesting at the same time a local exhibition of a strong solution as a wash or gargle, or in the form of trochisci.

The *Bromide* is reputable as an antispasmodic and nervine sedative, and is given in epilepsy, delirium tremens, convulsive seizures of children due to dentition, laryngismus stridulus, acute mania and loss of sleep.

The *Iodide*, unlike the chlorate, increases the secretion of saliva, sometimes to the point known as iodism.

Doses: Pot. chlorate, 0.65 Gm. (gr. x).

Pot. nitrate, 0.65 Gm.

Pot. bromide, }
Pot. iodide. } 0.65—200 Gm. (gr. x—xxx).

R. Potassii chloratis, 8 Gm. (ʒii).

Aqua, 250.00 fGm. (fʒviiij).

M. S. A gargle in stomatitis.

CHAPTER VI.

SODIUM.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Na.	23.	0.97.	I.

SODIUM was discovered by Davy in 1807 by electrolytic decomposition of soda. It is a very abundant element, existing in enormous quantities as a chloride; in sea water, as rock salt, in salt lakes and mineral springs, in marine plants, and as a necessary constituent of animal juices.

Large deposits of the nitrate, *Chili saltpeter*, carbonate, and borate, occur in nature, also sodium and aluminum fluoride, and sodium silicates.

Sodium is a white soft metal; it melts at 95.5° (204° F). It decomposes water, but not with as much energy as does potassium; if the water, however, be warmed, or thickened with starch, the escaping hydrogen will ignite. The reaction corresponds to that of potassium.

Sodium chloride, NaCl , common salt, is obtained by mining rock salt, and by evaporating salt water. It is a transparent, colorless, crystalline, anhydrous

solid of sp. gr. 2.15, of an agreeable taste, slightly deliquescent, and dissolves in 3 parts of water.

There are two oxides of sodium, Na_2O , and Na_2O_2 , of no practical importance.

Sodium hydrate, or hydroxide, NaOH , caustic soda, is formed and held in solution when sodium is thrown into water; it is, however, practically prepared from the carbonate, in the same way that caustic potash is obtained. It is strongly alkaline, but not so active a caustic as the potassium salt. Its use in commerce is for refining fats and oils, and in making hard soaps.

Sodium Carbonate, Na_2CO_3 , is manufactured by several processes, but is mainly obtained from the chloride, by the "Leblanc process," the description of which is unnecessary. It crystallizes with 10 molecules of water, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, and is the "sal soda" of the laundries. When devoid of water, or *dry carbonate*, it is used in very large quantities in the making of glass and soap.

Sodium carbonate is strongly alkaline, owing to the strong base and the weak acid, in its composition. If it be subjected to the direct action of carbonic acid, the "*bicarbonate*," Na HCO_3 , a mild alkali will be produced. This is the cooking soda of the kitchen, is an ingredient of all baking

powders, and of many effervescent drinks, and is also used in medicine.

Sodium Borate $\text{Na}_2\text{O}, 2\text{B}_2\text{O}_3, 10\text{H}_2\text{O}$ *borax*, occurs native, in colorless crystals, slightly effervescent, and mildly alkaline; soluble in water and glycerine, but not in alcohol. It is used in the arts as a flux in melting, soldering, and welding certain metals. When heated, it swells up, losing its water of crystallization, and then subsides as a vitreous mass (borax glass), which is removed from the surface of the soldered metal, by dilute sulphuric acid. A solution of borax (or solutions of sodium carbonate, or of alum) will render dried plaster casts comparatively hard.

Other compounds of sodium are numerous, and some of them important; they resemble for the most part, the corresponding compounds of potassium.

MATERIA MEDICA. *Sodium Chloride* is a flesh preserver, and may be considered a good prototype of *antiseptics* in general.

Labarraques Solution, liquor sodæ chloratæ, solution of chlorinated soda, NaCl , NaClO , analogous to common bleaching powder. Locally, it acts as a *disinfectant*, destroying malodorous and infectious matter, by reason of the free chlorine and free oxygen it evolves, in the presence of acids (carbonic

acid of the air); for the same chemical reason it is a good bleaching agent, if combined with powdered alum.

The *bicarbonate* is used locally as an antacid, and when mixed with water, as an application to burns and scalds.

Borax is a mild antacid, antiseptic, refrigerent, and detergent. It is a useful ingredient of mouth washes, or gargles, in inflammation of mouth or throat, combined with sweetening correctives, as honey, glycerine, etc.

When internally administered the sodium salts have not the depressing influence on the system possessed by those of potassium.

Dose. Sodii Bicarbonas, } 1.00 Gm. (gr.xv).
Sodii Biboras, }

R. Sodii Boras, 4.00 Gm. (ʒi).

Mellis.

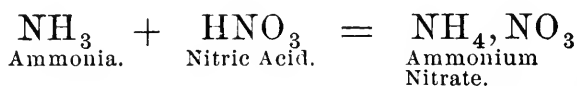
Aqua aa, 30.00 fGm. (fʒi).

M. S. Use as a detergent.

The other metals of the alkalies, viz., lithium, rubidium, and cesium, are also monads, and are comparatively rare. They are highly oxidizable; cesium being the most highly electro-positive of all elements; they decompose water, setting hydrogen free, and form alkaline caustic hydroxides.

Ammonium, NH_4 , is a hypothetical, univalent,

electro-positive, compound *radical*. Although it has not been isolated, it acts like metals in the formation of various salts, being developed in reactions between ammonia, NH_3 , and other bodies containing hydrogen. Thus, ammonia and nitric acid, HNO_3 , unite with each other, without setting any hydrogen free; the hydrogen of the acid, probably joins itself most intimately to the NH_3 , to form the radical NH_4 , which then, like an atom of potassium, unites with the electro-negative radical, NO_3 .



Ammonium salts are numerous, and resemble in many respects the corresponding salts of the alkali metals. The hydroxide, $\text{NH}_4 \text{OH}$, is an alkaline caustic, which, when dilute, gives up free ammonia, and is employed by inhalation as a stimulant in ordinary syncope, and in excessive anæsthetic narcosis.

The *Chloride*, NH_4Cl , the “sal ammoniac” of commerce, is used as a flux in refining gold; and as a local stimulant to indolent ulcers. The *carbonate*, which has a rather complicated formula, is known as “sal volatile,” and is the principal substance in “smelling salts.”

CHAPTER VII.

CALCIUM, ETC.

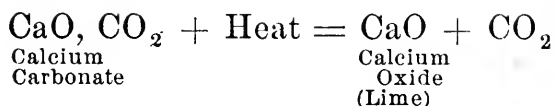
Symbol,	At. Wt.	Sp. Gr.	Valency,
Ca.	40.	1.50.	II.

CALCIUM is not found free in nature, but exists abundantly in combination. As carbonate it occurs in limestone, marble, chalk, coral, marl, oyster shells, Iceland spar, the stalactites and stalagmites of certain caves, and in bones and teeth; as a fluoride, sulphate, phosphate, and in many silicates.

The metal itself is brilliant, slightly yellow, somewhat hard, very malleable and ductile, oxidizes slowly in the air, decomposes water, and when heated burns with an extremely bright light. It may be obtained by heating the *iodide* with sodium, but singly it is of no practical use.

Calcium forms but one chloride, CaCl_2 , which occurs as a waste product in many processes.

Calcium oxide, CaO , *lime*, is always prepared on a large scale by heating the carbonate, as limestone, in a lime kiln. The carbonate being composed of calcium oxide and carbon dioxide, the latter is driven off by the heat, as will be easily understood by the equation.



Lime is a hard, infusible, white solid. When *slaked* with water, which union develops great heat. Calcium hydroxide, $\text{Ca}(\text{HO})_2$, is formed a white, bulky powder, which, in an excess of water dissolves, resulting in a clear alkaline liquid, known as lime water. Lime water readily absorbs CO_2 from the air, as does also milk of lime (whitewash), and the lime of mortars and cements. It is to this fact that the hardening of cements, made largely from lime is due; the absorption of the CO_2 , forming a quasi limestone, a true carbonate. When sand is present, calcium silicate is also formed.

Calcium Carbonate exists in so many forms in nature, as already noticed, that its description seems superfluous. It is soluble in water containing carbonic acid, as nearly all natural waters do, therefore such waters, in limestone regions, are *hard*. They may be rendered soft by boiling, which drives off the carbonic acid; or by an alkali, like ammonia, which takes up the acid, whereby the lime salts are precipitated.

It is probably owing to similar reactions that occasion the deposition of *tartar* on the teeth.

The fluids of the parotid, and submaxillary

glands, holding lime salts in solution, by aid of the carbonic acid present, upon their egress into the mouth, meet with free alkalies, the results of putrefaction change, which take up the carbonic acid; the removal of the acid, thus, deprives the saliva (water) of its ability to hold the lime salts in solution, and they are precipitated.

Calcium sulphate occurs in nature as *alabaster* and *selenite* and en masse as *gypsum*, $\text{CaSO}_4, 2\text{H}_2\text{O}$. When heated sufficiently, gypsum loses its water of crystallization, and becomes plaster of Paris; this *plaster* readily takes up water again, and "sets" to a hard solid. It is used in taking impressions, and in forming models of the parts to be supplied with artificial dentures; and also for making molds and casts of various kinds.

Calcium Phosphate, $\text{Ca}_3(\text{PO}_4)_2$, *bone phosphate*, is found in natural deposits in certain portions of South Carolina, Florida, and the islands of the Carribean sea, supposed to be the remains of vast numbers of marine animals that were gradually imprisoned in the now extinct salt water lagoons, by land appearing between them and the ocean. It is the principal constituent of bones and teeth; it is found also in the other tissues, and in calculi. Prepared as precipitated calcium phosphate, it is a white, tasteless and odorless powder, insoluble in

water and alcohol, but freely soluble in even weak acids.

Calcium Fluoride, CaF_2 , fluor spar, constitutes about two per cent. of human bone and enamel.

Chlorinated Lime, CaCl_2O , bleaching powder, sometimes improperly called, *chloride* of lime, is formed by action of chlorine on slaked lime; occurs as a gray white powder, or in lumps slightly moist, emitting a faint chlorine odor, soluble in water, and decomposed by the carbonic acid of the air (likewise by other dilute acids) into free chlorine, and other bodies. By the influence of the nascent chlorine on the hydrogen present in the moisture, active oxygen results. The preparation, therefore, is an excellent *disinfectant* and bleaching agent.

Oxygen is set free *en masse*, by acting on a solution of the powder with a solution of nitrate of cobalt.

For bleaching teeth, the dry powder may be incorporated with tartaric acid, introduced into the cavity slightly moistened, and covered with gutta percha.

MATERIA MEDICA. Some of the lime preparations used locally are sedative and soothing, as linimentum calcis (lime water and linseed oil), applied to burns.

Prepared chalk is probably the basis of all tooth powders; it acts as an antacid and astringent. When taken internally, lime and chalk act in the same way.

The *phosphate* has been recommended, although its efficacy is doubtful, as a food supply, whenever the structural pabulum in growing bones of infancy and childhood is deficient.

Doses. Liquor Calcis, 8.00 fGm. (fʒij).
Creta Præparata, 1.00 Gm. (gr.xv).
Calcii Phosphas. Præcipitata, 1.50 Gm. (gr. xx).

R. Calcii phos. præcipit, 4.00 Gm. (ʒi).
Mistura Cretæ, 125.00 fGm. (fʒiv).

M. S. Give a teaspoonful to child at meals.

The two other elements of the calcium group, strontium and barium, are comparatively rare and unimportant, strontium nitrate $\text{Sr}(\text{NO}_3)_2$ is used in making "red fire," barium nitrate $\text{Ba}(\text{NO}_3)_2$ in making "green fire."¹ Barium salts are used as a test for sulphuric acid, and *vice versa*. Barium sulphate is known as "heavy spar," and when ground is used as a pigment.

There are two oxides of barium, and these are easily changed, the one into the other. BaO heated in air, is converted into BaO_2 . This dioxide readily gives up O, as in the manufacture of hydrogen dioxide, already alluded to.

CHAPTER VIII.

METALS OF THE EARTHS, AND SILVER.

The metals of the earths—yttrium, erbium, samarium cerium, etc.—are quite numerous, but are found only in a few rare minerals, principally as silicates. They, and nearly all their compounds, are mere chemical curiosities, except cerium oxalate, $\text{Ce}_2 (\text{C}_2\text{O}_4)_3$, which is used in medicine.

SILVER.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Ag.	108.	10.5.	I-III.

SILVER has been known from the earliest times. It is found in various countries, in the metallic state, but principally in combination, as chloride, iodide, bromide, sulphide and telluride. The various elaborate methods employed for extracting silver from its ores are interesting from a commercial chemical point of view, but need not be considered here.

It is a brilliant white metal, malleable, and ductile, and is the best conductor of heat and electric-

ity. It melts at about 1000° (1850° F), does not tarnish in pure air, although traces of H_2S affect it, as it sulphidizes easily; it is also readily acted on by Cl and P; hydrochloric and sulphuric acids attack it with difficulty, but nitric acid, even quite dilute, rapidly dissolves it.



Silver Nitrate AgNO_3 , lunar caustic, is obtained according to the above equation; by evaporating the solution, it appears in the form of colorless, transparent, anhydrous crystals, soluble in water and alcohol. When melted and cast into proper shape, it is known as lunar caustic.

Silver nitrate is employed in photography, in the making of hair dyes, indelible ink, etc., on account of its turning dark by the influence of light, when in contact with organic matter, probably due to the deposition of argentous oxide.

Silver Chloride, AgCl , is precipitated whenever a soluble chloride (common salt, etc.), is added to a solution of silver nitrate. It is a white curdy substance, insoluble in water and nitric acid, but dissolves easily in aqueous solutions of ammonia and potassium cyanide. When heated, it fuses, and on cooling, assumes a horny consistency, hence the name of the mineral *horn silver*.

Silver chloride decomposes in the light, rapidly, when in contact with organic matter; also when heated with sodium carbonate, or placed in dilute sulphuric acid with zinc or iron. In the latter process, the nascent hydrogen removes the chlorine, leaving the silver in the form of a spongy mass.

There is another chloride of silver of uncertain constitution; and three oxides. The normal oxide, Ag_2O , a strong base, which yields salts isomorphous with those of the metals of the alkalies.

MATERIA MEDICA. The *nitrate* is the only silver compound that need be noticed in this connection. It is employed almost exclusively as a local agent, and possesses decided caustic properties, by reason of its coagulating action on albumen; by this means, a protecting pellicle is soon formed, which prevents the caustic action from extending deeply. It is used to induce healthy granulations in ulcers and wounds, and when properly diluted, is one of the most efficacious applications to every variety of inflammation of the mucous membrane.

Applied in substance to sensitive abraded, or denuded, or even decayed surfaces of teeth, it relieves the tenderness and arrests the process of decay. On account of the permanent darkening of the tooth substance to which it is applied, especial discretion should be observed in its use.

Dose. Silver Nitrate, 0.01 Gm. (gr. $\frac{1}{6}$).
Antidote, common salt.

R. Argenti Nitras, 0.10 Gm. (gr. jss).
Aqua Dest., 30.00 fGm. (f $\overline{3}$ i).

M. S. Injection in diseased antrum.

CHAPTER IX.

COPPER, MERCURY.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Cu.	63.	8.95.	II.

COPPER is one of the ancient metals and is still of great value in the arts. It is found in nature both native and in combination, as oxide, carbonate, and sulphide, and with iron sulphide as "copper pyrites."

Copper has a familiar yellowish-red color; is malleable and ductile and tenacious; is one of the best conductors of electricity and heat; melts at about 1090 (1994-F), is not acted on by dry air, but in moist air it tarnishes with a green crust, consisting principally of the carbonate. When heated, scales of black cupric oxide form on its surface. Chlorine, sulphur, and nitric acid attack it readily; in the latter case, setting free fumes of N_2O_2 . It also forms salts with dilute acetic acid and hot sulphuric acid, and slowly, with dilute hydrochloric and sulphuric and carbonic acids, alkalies and saline solutions. All soluble salts of copper are poisons.

Certain alloys of copper have been mentioned. Its compounds are numerous, but few of them need be considered here.

Copper forms two series of salts, the *cupric* and *cuprous*.

Cupric chloride, CuCl_2 , obtained by dissolving cupric oxide in hydrochloric acid, and by direct action of chlorine. It makes, with water, a green solution which, on evaporation, deposits green crystals containing water, $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$. When heated it loses all its water of crystallization, and half its chlorine, and is converted into *cuprous chloride*, Cu_2Cl_2 , a white fusible substance, slightly soluble and prone to oxidation. Both chlorides form double salts, with the chlorides of the alkali metals.

Cupric oxide, CuO , or *black oxide* of copper, may be prepared by heating copper in air, or by calcining the nitrate, carbonate, or hydrate. It unites with most acids, forming cupric salts. With phosphoric acid it forms a hard, tenacious, insoluble, black mass, which combination has been introduced by Dr. W. B. Ames, as a filling material in posterior teeth, for setting crowns, etc. The mineral libethenite is HCu_2PO_5 .

Cuprous oxide Cu_2O , red oxide of copper, is like

the other cuprous compounds, important only as conferring a beautiful ruby red color to glass.

Cupric sulphate, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, *blue vitriol*, prepared by dissolving cupric oxide in sulphuric acid, occurs in large blue crystals, and is extensively employed in electro-metallurgy, telegraph batteries, calico printing, the making of Paris green, etc.

MATERIA MEDICA.—*Copper sulphate* in substance is an excellent application to fungous conditions of the gums, as it acts as an astringent and lessens the local blood supply, and is a mild caustic.

Internally in large doses it acts as an emetic, in small doses as a tonic.

Dose. (Emetic), 0.20 Gm. (gr. iij).
(Tonic), 0.02 Gm. (gr. $\frac{1}{3}$).

MERCURY.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Hg.	200.	13.59.	II.

MERCURY, *quicksilver*, the *argentum vivum*, of the ancients, is found native, but principally as a sulphide, *cinnabar*, extensively mined in California, Mexico, and Peru, and portions of the old world. The sulphide is reduced by roasting with lime, the metal volatilizes and is condensed in suitable chambers.

Mercury is a brilliant silver-white liquid. At

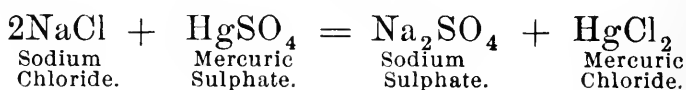
40°C (and F) it solidifies to a tin-like malleable mass of specific gravity 14.19. It is slightly volatile at 15° (60-F) and boils at 357 (666-F); yields a vapor of density of 100; the molecule of mercury, therefore, consists of one atom. Mercury is unaltered by the atmosphere, but near its boiling point it slowly absorbs oxygen, passing into the red oxide, HgO . Chlorine and sulphur unite directly with mercury. Boiling strong sulphuric, and even dilute nitric acid attack it easily, but it is unaffected by hydrochloric and cold dilute sulphuric acids.

Mercury is used in the making of many physical instruments, as thermometers, barometers, etc., and in extracting gold and silver from their ores. Its alloys are called *amalgams*. Of these, only those used for filling careous teeth are of special interest to us. *Copper* amalgam is produced by various processes, among the best, perhaps, being by electrolysis of copper sulphate in the presence of mercury. It is a hard amalgam when properly made; does not change in bulk or shape in setting, and acts as a germicide and antiseptic. It, however, dissolves in weak acids, and the decidedly black copper oxide and sulphide which, together, form on the surface, are probably converted into copper sulphate, which we know to be freely soluble. Both of these facts combined, or either one

singly, can explain satisfactorily the *wasting* that so often takes place in copper amalgam fillings.

Mercury forms with many other metals, amalgams of either continued pasty, or hard consistency, according to the metal used. An amalgam of an alloy of about 50 parts silver and 40 parts tin, containing also small additions of copper, gold, zinc, platinum, palladium, antimony, and cadmium, singly or otherwise, seems to produce the best results in dental practice. The *blackening* of amalgam fillings is due to the formation of metallic sulphides, and is considered a not unmixed evil; the more emphatically *black*, the better the preserving qualities.

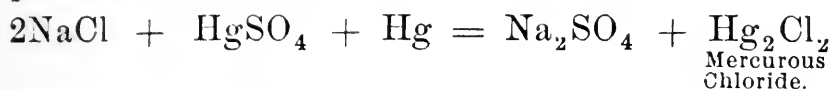
Mercuric chloride, HgCl_2 , bichloride of mercury, corrosive chloride, corrosive sublimate, etc., is usually prepared by subliming a mixture of sodium chloride and mercuric sulphate.



Mercuric chloride is a semi-transparent crystalline heavy solid, of an acid metallic taste, and acid reaction. It is soluble in 16 parts of cold, and 2 parts of hot water, 3 of ether, and 2 of alcohol, and is a strong corrosive poison.

Mercurous chloride, Hg_2Cl_2 , proto-chloride of mercury, mild chloride of mercury, submuriate, *calomel*, etc. Calomel occurs native, in tetragonal

crystals, but is commercially prepared by subliming a mixture of sodium chloride, mercuric sulphate and mercury.



A heavy white, fine powder condenses, insoluble in water, and alcohol, tasteless, and decomposes slowly in sunlight into free Hg and HgCl_2 .

Mercuric oxide, HgO , occurs in red scales, when mercury is heated in air, commonly as red precipitate. It forms with acids, mercuric salts.

Mercurous oxide, Hg_2O , a black powder, produced by action of alkali-hydrates on calomel. With acids it forms mercurous salts. There are two iodides of mercury analagous to the chlorides.

Mercuric sulphide, HgS , has already been alluded to as the mineral cinnabar. When made synthetically it is known as the brilliant red pigment, *vermilion*.

Mercurous sulphide Hg_2S , is a black powder, known as ethiopes mineral.

Mercuric chloramide, $\text{Hg} \begin{Bmatrix} \text{Cl} \\ \text{NH}_2 \end{Bmatrix}$ is known as white precipitate.

MATERIA MEDICA.—Mercurial preparations are favorite local remedies in certain skin diseases and syphilitic ulcerations, in virtue of their germicidal and antiseptic properties. The practice of steril-

izing instruments in *hot* solutions of mercuric chloride is effective, although the efficacy of a *cold* solution might be questioned. A cold aqueous solution of this drug has been a favorite germicide in sterilizing root canals of teeth, preparatory to filling. It forms, with albuminous matter, a coagulum of only temporary existence, consequently, the duration of asepsis, secured by it, is limited; and unless the disease germs, held in the coagulum, are immediately *killed* by it—a wished-for consummation, the occurrence of which, many deny—its virtues as a germicide and antiseptic would be active only during the period of coagulation; and if more or less organized matter remain in the canals, at the time of filling, a condition that unfortunately sometimes obtains, its coagulation by corrosive sublimate, would therefore be of doubtful permanent efficiency. The salts of mercury, nevertheless, appear to possess especial destructive power over the germs of syphilis at least, and a wash of corrosive sublimate solution, used before operating in the mouth of a syphilitic patient, would sterilize the part for the time being.

Taken internally, the salts of mercury if pushed to the limit, occasion nervous debility, and cause anæmia by destroying the red corpuscles. They increase the secretion of saliva, *mercurial salivation*

sometimes following their use. Antidote to mercuric chloride—emesis, albumen, white of egg, milk, flour.

Dose. Mercuric Chloride, 0.004 Gm. (gr. $\frac{1}{16}$).

Mercurous Chloride, 0.30 Gm. (gr. v).

R. Hydrarg Chlor. Corrosiv. 0.10 Gm. (gr.jss).

Acidi Hydrochlorici Dil., q. s. ad. solve.

Mellis Depurati, 15.00 fGm. (f 3 ss).

Aqua Dest., q. s. 150 fGm. (f 3 v).

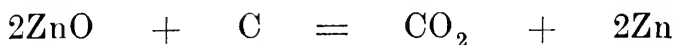
M. S. To be used as a wash, or gargle, in syphilitic ulceration of mouth and throat.

CHAPTER X.

ZINC, ETC.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Zn.	65.	7.	II.

THE chief ores of zinc are the sulphide, carbonate, oxide, and silicate. These are calcined in air, producing zinc oxide; the latter is then distilled with charcoal (C), which takes up the oxygen, the zinc vapor condensing in suitable vessels.



Zinc is a bluish white metal. At ordinary temperatures it is hard and brittle; at about 150° (300°F), it becomes quite malleable; at 200° (392° F), it again becomes brittle, and may be broken up in a mortar; at 412° (773°F), it melts, and at about 1000° (1832°F), if air be present, it volatilizes and burns with a splendid greenish light, forming its only oxide, ZnO. Zinc is slowly oxidized in moist air, and is acted on easily by dilute acids, by alkali-hydrates, and by the halogens. It is used largely as a protecting coat for sheet iron; it forms the positive element of galvanic batteries, in making dies for swaging dental plates, as a constituent for some

amalgams, and of other highly valuable alloys, as brass, etc.

Zinc chloride, ZnCl_2 , is made by direct action of chlorine upon zinc, or by dissolving granulated zinc, or zinc carbonate in hydrochloric acid, purifying by solution of chlorine and zinc carbonate, and evaporating the solution to dryness. It occurs as a grayish-white translucent, crystalline mass, deliquescent, and very soluble in water, and in alcohol, and ether. *Liquor zinci chloridi*, is the official preparation, and contains 14.00 Gm. (3ijss) of zinc chloride to 30.00 f Gm. (f3i) of water. The solution for oxy-chloride cement should have a sp. gr. of about 1.50.

Aside from its use in surgery, zinc chloride is employed as a chemical dehydrating agent; that is, it will not only take away water, but the elements of water from organic compounds (and from albuminous organized structure, which probably explains its action as a caustic). It is also used as a soldering fluid.

Zinc oxide, ZnO , is the product of the combustion of zinc in air; it is used extensively as a pigment. The pharmaceutical preparation is obtained by subjecting pure precipitated zinc carbonate to a red heat, until all the water and CO_2 are driven off. It should appear as a white, smooth, impalpable powder. It is tasteless, and insoluble in water, but

is acted upon by the common dilute acids. It is the basis of the various zinc cement preparations, mixed with variable quantities of silica, borax, pulverized glass, etc

The liquid for the oxychloride has already been described; that for the oxyphosphate consists of tri-basic phosphoric acid, H_3PO_4 , prepared by dissolving pure glacial phosphoric acid, HPO_3 , in warm water and evaporating to a syrupy consistency.

In preparing the filling, the powder should be added to the liquid slowly, and mixed thoroughly, until the magma has a stiff, tenacious feel, then inserted in place, and kept dry for 20 or 30 minutes. The result will be a hard coherent filling, of reasonably lasting qualities, depending more than less, on its position in the tooth. Chemical union between the acid, and the *zinc oxide* of the powder, undoubtedly takes place; the other ingredients of the powder being held mechanically; but this union can be overcome by either acids or alkalies. It is known that these fillings give way rapidly at the cervical wall, if under, or near the gum margin; such positions are most favorable to development of alkalies, by putrefaction (ammonia, and its derivatives, the amines, amides, ptomaines, etc.), and also somewhat to acid fermentation. The alkali

will appropriate its equivalent of the phosphoric acid, the cement losing its integrity to that extent; while the acid stage of fermentation, if such should occur, would tend to destroy the cement, by attracting the oxide of zinc. In such a situation the oxyphosphate fillings are, evidently, "between the devil and the blue sea."

Zinc sulphate, $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$, white vitriol, obtained by the action of sulphuric acid on granulated zinc, occurs in small, colorless, efflorescent crystals, soluble in water, insoluble in alcohol, and of a metallic styptic taste.

MATERIA MEDICA. *Zinc chloride is a powerful caustic*, owing to its dehydrating qualities. It is employed in substance, or strong solution, for treatment of cancerous and other forms of ulceration. As an obtunding agent to sensitive dentine, it is affective, although superficial; but on account of the pain immediately following, and the danger to the vitality of the pulp involved, the practice of applying it as a dentinal obtundant, has been nearly abandoned. In solution, it is successfully employed as an injection in chronic alveolar abscess, in antrum disease, and in the gum pockets of alveolar pyorrhœa.

The *sulphate* acts locally as an astringent and stimulant.

Internally, the sulphate is tonic, antispasmodic and astringent. In large doses it is the favorite direct emetic.

Dose. Zinc Chloride 0.03 Gm. (gr.ss.)
 Zinc Sulphate 0.06–0.30 Gm. (gr. j–v.)
 As an emetic—Zinc Sulphate 0.65 Gm. (gr. x.)
 Antidote, Sodium bicarbonate.

R. Zinci Chloridi 0.06 Gm. (gr.j).
 Aqua Rosæ 30.00 fGm. (fʒi.)

M. S. A good injection, Antrum, etc.

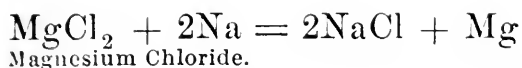
MAGNESIUM.

Symbol.	At. Wt.	Sp. Gr.	Valency.
Mg.	24.	1.75.	II.

MAGNESIUM is an abundant element, but is always found in nature in combination. The double carbonate of magnesium and calcium MgCa_2CO_3 is known as *dolomite* or mountain limestone, of which whole mountain ranges are formed. The metal also occurs in the single carbonate; the sulphate, hydrate, fluo-phosphate, chloride and several silicates, of which latter class, *meerschaum* is one (2MgO SiO_2).

Salts of Magnesium are found in sea water and many mineral springs, also in animal and vegetable bodies.

The element itself is generally obtained by heating the chloride with metallic sodium.

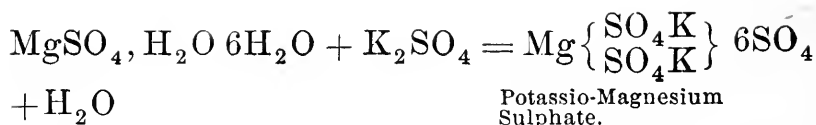


It is a bluish white brittle metal, somewhat malleable and ductile; melts at a red heat; is not affected by dry air, but oxidizes in moist air. Heated to redness, it takes fire, and burns with an extremely brilliant white light, very rich in the actinic chemically active ways; for this reason it is used as a source of illumination, in photographing the interior of caves, etc.

Magnesium Oxide, MgO , is a white, infusible, insoluble, bulky, antacid powder, known as *magnesia*.

Magnesium Sulphate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, is found in nature, as *Epsom salts*, and may be prepared by dissolving the oxide, hydrate, or carbonate, in sulphuric acid. It consists of colorless, odorless, soluble crystals, of a bitter taste; used in medicine as a purgative.

An interesting feature in connection with the water of crystallization in $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, is worthy of notice. At a temperature of 120° (248°F .) only six of the seven molecules of water are driven off; the remaining molecule persistently resisting expulsion until the temperature reaches nearly 200° (392°F .) This last is known as water of *constitution*, and may be replaced by certain sulphates, as for instance K_2SO_4 , yielding a *double sulphate*.



This compound serves as a type of double salts, and is isomorphous with those produced by the union of the alkali-sulphates, with the sulphates of zinc, copper, nickel, iron and cobalt



Potassio-Ferrous Sulphate,

Showing also that there is some chemical relationship between magnesium and the metals just named.

CADMIUM (Cd), is comparatively rare, occurs chiefly as an impurity in zinc, and as a sulphide; the precipitated sulphide, CdS, is a yellow pigment of great beauty, highly prized by artists. Cadmium is obtained by converting the sulphide into oxide, and reducing the latter, by heating with charcoal. It is a lustrous bluish-white, tinlike metal, of sp. gr. 8.6, at. wt. 112, vapor density one-half the atomic weight, hence its molecule is composed like that of mercury, of only one atom. It melts at 260° (500F.) · tarnishes gradually in the air, and is acted on slowly by acids, and by chlorine, sulphur, and oxygen. Its salts resemble those of zinc; the metal itself is malleable and ductile,

but of no importance, except as a constituent of some fusible, and amalgam alloys.

BERYLLIUM or GLUCINUM. (Gl), is a rare metal, occurring in certain silicie minerals, and as an aluminate. It is a white metal of sp. gr. 2.1 malleable, and sets hydrogen free from acids. Its salts have a sweetish taste, whence its former name, *glucinum*.

CHAPTER XI.

LEAD, ETC.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Pb.	206.5.	11.40.	II-IV.

LEAD was well known to the ancients, and is still an abundant and useful metal. It is found principally as a sulphide in galena, but also occurs as a carbonate, sulphate, phosphate and arsenate.

Lead is a bluish-white metal, soft enough to be easily cut with a knife. The brilliant freshly cut surface quickly tarnishes in moist air. It is malleable and ductile, but possessed of very feeble tenacity; melts at 320 (608F); is acted upon by nitric, sulphuric, hydrochloric, carbonic, and acetic acids, and by oxygen, sulphur, chlorine, bromine and iodine.

All the salts of lead are poisonous. Waters containing nitrates from decomposed animal matter, and chlorides, are not safe when passed through lead pipes. Hard waters, however, containing carbonates, and sulphates, are relatively safe, as the lead carbonate forms an insoluble protecting crust on the interior lining of the pipe, unless a considerable amount of free carbonic acid is present. As a

precaution it is best to allow water that has been long standing in lead pipes, to flow until the fresh portion from the mains appears. Lead salts in water can be detected by adding a few drops of hydrochloric acid and then a strong solution of sulphuretted hydrogen. If lead is present, a dark brownish color will result.

Cylinders of metallic lead have been successfully employed for filling root canals of teeth, the lead sulphide and carbonate, formed therein, probably acting as antiseptics, but as these salts, especially the sulphide, injure the normal color of the tooth, the practice of using lead for such purposes, is not much in vogue. In dentistry lead is more especially used for making counter-dies. In the arts it is used alone, and alloyed with other metals, for various purposes.

Its compounds are important. Lead oxides are used as coloring for porcelain teeth. The hydrated carbonate, $2\text{PbCO}_3, (\text{HO})_2$, is the basis of the well-known paint, *white lead*. The monoxide, PbO , is known as *litharge*, and this, if heated in a current of air, is converted into *red lead*, Pb_3O_4 .

MATERIA MEDICA.—All the salts of lead are used, as a rule, only as external applications. They are soothing and astringent. The *acetate*,

$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$, *sugar of lead*, is sometimes given internally as an astringent, in diarrhœa and hæmoptyses.

Lead poisoning (painters' colic), indicated by a blue appearance along the gum margins, muscular weakness (drop wrist), constipation, etc., is a frequent affection of workers in lead pigments.

ANTIDOTES.—Soluble sulphates, as magnesium sulphate, which cause formation of insoluble, and therefore, innocuous lead sulphate, followed by potassium iodide and sulphur baths.

Dose of lead acetate (*sugar of lead*), 0.10 Gm. (grjss).

The metal THALLIUM (Tl), discovered by Crookes in 1861, by aid of the spectroscope, is a very rare element, although widely diffused; occurring in very small proportions in iron and copper pyrites and in native sulphur. It is obtained from the flue-dust of sulphuric acid works. Although it is a triad, it resembles lead in nearly all its properties. Its atomic weight is 203. The salts of Tl color the flame a brilliant green.

TIN.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Sn.	1.18.	7.29.	II–IV.

TIN is one of the metals of earliest antiquity. The principal ore of tin is the mineral cassiterite

stannic oxide, SnO_2 , found from time immemorial in England (Cornwall). Tin is now produced also in Borneo, Malacca, Banca, and to some extent in the United States, South America, and Australia, the purest coming from the island of Banca.

The metal is obtained by heating the crushed ore, with coal or charcoal, $\text{SnO}_2 + \text{C} = \text{CO}_2 + \text{Sn}$. It is soft, white, crystalline, malleable, slightly ductile, and feebly tenacious. Melts at 235° (455°F), has a peculiar odor, and "cries" when a bar of it is bent; retains its luster in air at common temperatures, but if heated, oxidizes readily; is acted upon by dilute acids, and by the alkalis.

Tin is used largely in the arts; common *tin plate* is sheet iron, coated with tin, by immersion. Tin enters into the formation of many important alloys, and is used by dentists in the form of foil, as a filling material, alone, and in mechanical combination with gold. The high preserving qualities of tin in this connection, are doubtless due to the formation between the filling, and the walls of the cavity, of the insoluble stannic oxide, and when with gold, in addition to this, an electrolytic mutual induction continues between the two metals, like that which exists in, and preserves, *galvanized iron*, (iron and zinc).

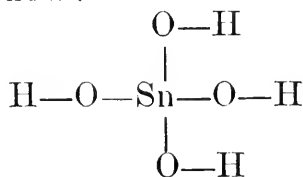
There are *two* sets of tin compounds. The two

chlorides, viz.: SnCl_2 and SnCl_4 , plus water of crystallization, are used as mordants in calico printing. These two chlorides, obtained by dissolving tin in hydrochloric and nitrohydrochloric acids respectively, yield with auric chloride, the beautiful "purple of Cassius," which is used in coloring porcelain.

Stannous oxide, SnO , is basic, and with acids forms a number of salts.

Stannic oxide, SnO_2 , is peculiar, when compared with those metallic oxides we have thus far considered, in being neither decidedly *basic*, nor *acid*; it is weakly basic with strong acids, and weakly acid with strong alkalies. This oxide is known as *putty powder*.

There are two acids of tin, whose formulas will serve to explain the meaning of the prefixes, *ortho* and *meta*, which are sometimes attached to the names of certain acids and salts. *Orthostannic acid*, H_4SnO_4 , has four hydroxyl groups in its molecule; all its oxygen has a linking function, as the graphic formula will show:



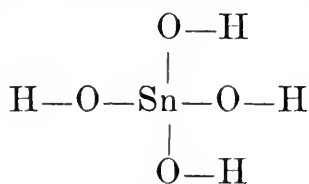
—Sn—being a tetrad, requires four groups of

hydroxyl groups

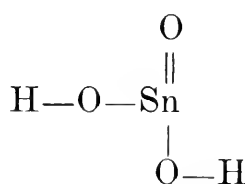
to form the

hydroxyl (OH)₄, to satisfy its equivalency of *four*. In all ortho-acids, there should be as many hydrogen atoms as oxygen atoms; that is, the number of hydroxyl (OH) groups should be the same as the valency of the receiving radical, which, in the case of Sn, is four. Phosphorus is a pentad, P^v. Ortho-phosphoric acid should therefore have *five* hydroxyl groups P(OH)₅.

Meta-acids are derived from ortho-acids by abstracting a molecule, or molecules of water, from the latter. In meta-acids the atoms of oxygen serve a *saturating* as well as a linking purpose. Thus, Meta-stannic acid, H₂SnO₃, is ortho-stannic acid, minus one molecule of water:

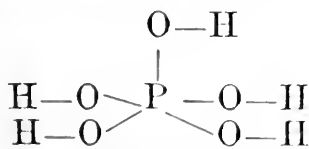


Ortho-Stannic Acid.

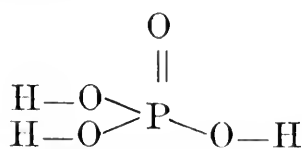


Meta-Stannic Acid.

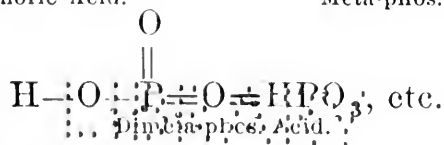
Where *two* molecules of water can be removed from an ortho-acid, a *dimeta*-acid results; *three* molecules of water removed, a *trimeta*-acid, etc.



Ortho-phosphoric Acid.



Meta-phos. Acid.



Dimeta-phos. Acid.

, etc.

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The salts of ortho and meta-acids are named with corresponding prefixes.

Stannic sulphide, SnS_2 , is a golden yellow powder, called "Mosaic gold," used for bronzing.

MATERIA MEDICA. The medicinal value of tin compounds is *nil*.

TITANIUM, ZIRCONIUM and THORIUM, belong to the *tin group* of elements. They are extremely rare; are tetrads, like carbon, silicon, and tin, to whom they are closely related in the gradation of their physical properties, and in the similarity of their chemical compounds. The gradation being in the following order:

Carbon, Silicon, Titanium, Zirconium, Thorium,
Tin.

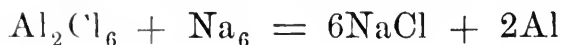
CHAPTER XII.

ALUMINUM, ETC.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Al.	27.	2.6.	IV.

ALUMINUM next to oxygen, and silicon, is the most abundant of the elements, the crust of the earth being made up mainly of those three. The minerals, corundum, emery, ruby and sapphire, are aluminum oxide, and the various kinds of clay, as well as feldspar, mica, slate, granite, basalt, etc., are essentially aluminum silicates. Hydraulic cement contains al-silicate.

The process of Deville, discovered in 1854, of heating together in a reverberatory furnace a definite mixture of fluor spar, sodio-aluminum chloride and metallic sodium, furnishes a clue to the methods adopted, for obtaining the metal.



This process has been superseded of late years by various modifications, by which aluminum is produced almost pure, (98 per cent), and comparatively inexpensive.

Aluminum is a brilliant bluish-white metal, susceptible of receiving a high polish; is very malle-

able, ductile, and possessed of considerable tenacity. It is acted on by aqueous solutions of strong alkalis and hydrochloric acid, but is unaffected by other cold acids, inorganic or organic; is not affected by sulphur, and therefore may be conjoined with rubber in vulcanizing the latter substance; it does not oxidize in bulk, but if thin leaves be heated in oxygen, it burns readily. It melts at 700° (1292°F).

On account of its lightness, permanent purity, and the tensile strength of the metal and its alloys, it is being largely introduced of late into the arts for many purposes. It can be cast alone or alloyed with silver or copper, into forms of singular beauty. 10 parts silver and 90 of aluminum exhibits a splendid white non-corrosive alloy; 90 parts of copper and 10 of aluminum, constitutes aluminum bronze, resembling gold in color, and capable of receiving and retaining a high polish. In thin leaves it has been used, with some success, as a lining for rubber plates. An alloy of 100 parts of aluminum and 10 of tin, is employed in the making of philosophical instruments. The apex of the Washington monument is of aluminum.

Aluminum plates, either cast or swaged for artificial dentures, have taken an important rank in

dental prosthesis. They possess special properties often requisite for certain mouths.

Alum, from which the metal takes its name, is the most important compound of aluminum. Common potash alum is a double sulphate of aluminum and potassium, $\text{Al}_2(\text{SO}_4)_3, \text{K}_2\text{SO}_4, 24\text{H}_2\text{O}$, or $\text{Al}_2\text{K}_2(\text{SO}_4)_4, 24\text{H}_2\text{O}$. Ammonium alum is $\text{Al}_2(\text{NH}_4)_2(\text{SO}_4)_4, 24\text{H}_2\text{O}$. There are alums also of Na, Cs, Rb, Ag, and Tl, wherein these elements respectively occupy the place of K or NH_4 ; and there are alums in which the aluminum itself is replaced by Fe, Cr, and Mn, respectively. Each molecule of alum contains 24 molecules of water of crystallization.

Ordinary alum is manufactured on a large scale by action of sulphuric acid on some of the various aluminum silicates, whereby aluminum sulphate, $\text{Al}_2(\text{SO}_4)_3$, is formed. This is then added in solution, to a solution of potassium sulphate K_2SO_4 , or ammonium sulphate NH_4SO_4 , as the case may be. The alum crystallizes on evaporation of the liquid mixture.

Alum has an astringent sweetish taste, and acid reaction; is soluble in water, the hot solution being a good *pickle* for removing borax glass from gold, etc., after soldering. By heating for a considerable time, at a temperature of 80° (176°F), all

the water of crystallization is driven out, the alum then becoming *caustic alum*.

Aluminum Oxide, Al_2O_3 , alumina, is found crystallized in nature, in many varieties, as corundum, emery, ruby, etc.; colored by impurities, as sapphire, which is simply *blue* corundum; "oriental amethyst" is purple, "oriental topas" is yellow, and "oriental emerald" is green. These gems can be produced artificially.

The *oxide* is prepared by igniting the *hydrate* (the latter obtained by mixing a solution of alum with excess of ammonia), presents a white, tasteless, coherent mass, very slightly affected by acids, and fusible only in the oxyhydrogen flame.

The *hydrate* $\text{Al}_2(\text{HO})_6$ ortho-aluminum hydroxide, prepared as above, forms with strong acids, characteristic salts, like al-sulphate, already mentioned. With basic radicals, it acts as an acid, forming *aluminates*, as ortho-sodium aluminate, $\text{Na}_6\text{Al}_2\text{O}_6$. There are also the mono-meta hydroxide, $\text{Al}_2\text{O}(\text{HO})_4$, and the dimeta-hydroxide, $\text{Al}_2\text{O}_2(\text{HO})_2$, forming with bases, mono-meta and dimeta-aluminates, respectively, as dimeta-potassium aluminate, $\text{K}_2\text{Al}_2\text{O}_4$, etc. Aluminum hydrates are largely used in calico printing, as *mordants*, inasmuch as they are able to unite with organic dye-stuffs, to form "lakes," which are insoluble; the

different colors being thus "fixed" in the fiber of the cloth.

There are normal, and basic (*i. e.*, containing hydrogen), aluminum phosphates found in nature, of which, the turquoise, $\text{Al}_4(\text{PO}_4)_2(\text{HO})_6, 2\text{H}_2\text{O}$, is an example. The topaz is fluo-aluminum silicate, the beautiful blue "lapis lazuli" is sodio-aluminum silicate, containing sulphur. Its powder was formerly used by artists, under the name of "ultra marine." This substance is now produced very cheaply; violet, red, and green ultra-marines are also prepared artificially.

Clay is the result of the disintegration of the unstratified, primitive rocks, as granite, porphyry, etc., and further of *felspar*, etc., these rocks consisting, in great part, of this mineral.

The art of pottery making has been known from the earliest times. Porcelain manufacture, in Europe, is of comparatively recent date, being derived, probably, from China, whence the name "China-ware." *Porcelain* differs from pottery, in being translucent, and differs from glass in being non-transparent, and much more infusible.

Porcelain clay, or *kaolin*, is a hydrous aluminum silicate —, $\text{H}_2\text{Al}_2\text{Si}_2\text{O}_8, \text{H}_2\text{O}$, derived by atmospheric influence on felspar, which is $\text{K}_2\text{Al}_2\text{Si}_6\text{O}_{16}$. When prepared for the furnace, and *baked*, it loses

its water, yielding a porous "biscuit." This is dipped in a thin mixture of pure felspar and water, and "fired" again; the felspar being fusible, "glazes" the surface into a smooth finished product. The ornamental part, of gilding, and painting in enamel, is next accomplished, and the piece (pieces) heated again to flux the colors. The colors consist of pigments of metallic oxides; cobalt oxide for blue, chromic oxide for green, etc.

Crucibles and fire-brick contain extra proportions of silica.

Porcelain teeth are manufactured by processes similar to those employed in making porcelain ware. The *body* consists chiefly of *felspar*, *kaolin* and *silica* (SiO_2); the *enamel*, mainly of *felspar*. The different shades of enamel are produced by fine division of various metals, or of metallic oxides (purple of cassius, for instance). A representation of a gold filling may be obtained by applying a mixture of precipitated gold, or auric chloride and chamomile oil to the limited part desired on the surface of the tooth, and heating. (See Gold.)

MATERIA MEDICA. ALUM, *alumen*, possesses styptic and astringent properties, condensing the tissues by coagulating their albumen; dried alum, *alumen exsiccatum*, is mildly caustic. In large doses,

taken internally, alum acts also as an emetic and purgative.

Alum is employed locally to arrest alveolar hemorrhage, and in solutions of varying strength, in treatment of spongy gums, of congested mucous membrane of mouth and throat, and for relieving the inflammation and soreness, induced by wearing artificial dentures, and as an injection in many flowing diseases; and as a collyrium. Powdered alum, added to *Labarraques* solution, makes an effective bleacher for discolored teeth.

Aluminum *chloride*, *sulphate*, and *acetate*, are *disinfectants* and antiseptics. Very weak solutions of either of these, will effectually neutralize offensive breath, arising from catarrhal affections.

The chloride is sometimes used for bleaching teeth.

Dose. Alum 0.65 — 1.00 Gm. (gr. x — xv).

Alum (dried), 0.25 — 0.65 Gm (gr. iv — x).

R. *Aluminis*, 4.00 Gm. (ʒi).

Tinctura myrrhæ, 15.00 fGm. (fʒss).

Aq. Dest. q. s. ad. 60.00 fGm. (fʒij)

M. S. Apply to spongy gums.

GALLIUM,

INDIUM, etc.,

Ga.

In.

These metals are chemically related to aluminum. They are extremely rare, only traces of them being

found in zinc blende. The atomic weight of Al is 27, of Ga 70, and of In 114, a regular gradation; the specific gravity of Al is 2.6, of Ga 5.9, and of In 7.4, a regular gradation. Both gallium and indium were discovered by spectrum analysis. Their sulphates form ammonia alums.

Gallium, and the rare metal *scandium*, are of especial theoretical interest, on account of their existence and properties, having been predicted in advance of their discovery.

CHAPTER XIII.

IRON.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Fe.	56.	7.8.	II, IV, VI.

Ever since the ante-historic times of Tubal Cain, who was a worker in iron, this metal has held its own as one of the most important substances in nature.

It is abundantly distributed, although but a very small quantity of native iron has been found; a large proportion of meteors consist of metallic iron. Iron is a constituent of innumerable minerals, is present in all kinds of rocks, and soils, in the waters of nearly all mineral springs, and in the bodies of plants and animals.

The ores from which iron is obtained, however, are practically very limited in number. These are, chiefly, magnetic oxide (magnetite), Fe_3O_4 ; ferric hydrate (limonite), $2\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$; ferric oxide (hematite), Fe_2O_3 ; and ferrous carbonate (siderite), FeCO_3 . Those ores that are not native oxides, are converted into artificial oxides by roasting, so that practically, the chemical process of producing

iron on a large scale consists essentially in reducing the oxide with carbon. Alternate layers of the ore, fuel, and limestone are placed in the "high furnace," and hot air forced upward through the mass, producing such a high temperature that the oxygen leaves the ore, and takes up with carbon, leaving iron in the metallic state:



The limestone serves as a flux in removing silica and other impurities, which fuse into a "slag," and remain on top of the molten iron. The process is continuous, until the furnace wears out; the materials being added at the top and the melted slag and iron drawn off at the bottom at regular intervals. The metal is drawn off into molds, and is known as *cast* or *pig iron*, and contains a good deal of carbon; this is burned off in a reverberating furnace, together with sulphur, silicon, phosphorus, and other impurities in the form of oxides. This operation is known as "puddling," the result being *wrought iron*.

The different varieties of commercial iron contain more or less carbon. *Cast iron* contains the most carbon, 2 to 6 per cent. Steel considerably less, 0.5 to 2 per cent, and wrought or malleable iron, less than 0.5 per cent.

Wrought iron is fibrous in structure, and *tough*;

at a high temperature it becomes *pasty*, in which condition it is susceptible of *welding*.

The melting point of iron is very high, probably above 2000° (3632°F). It is malleable when hot, and ductile, and possessed of superior tenacity; and when pure is *white*.

Iron is acted upon by hydrochloric, and sulphuric and dilute nitric acids, and by the haloids; and when heated, by phosphorus, sulphur, and oxygen.

It would be doing more than our requisite duty to attempt to name the uses to which iron is applied in the arts; and would be a work of supererogation also, to consider its numerous compounds in their chemical relation to commerce, the arts, and medicine.

Ferrous Salts, which may be regarded as derived from ferrous oxide, FeO , are mostly pale green in color.

Ferrous Sulphate, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, commonly called green vitriol, or *copperas*.

Ferrous Chloride, FeCl_2 , and *ferrous iodide*, FeI_2 , are pale green, and soluble. Ferrous sulphide, FeS , made by fusing iron and sulphur together, dissolves in dilute acids, with evolution of H_2S .

Ferrous Carbonate, FeCO_3 , a white precipitate, produced when solution of a ferrous salt, as FeSO_4 , is added to a solution of an alkaline carbonate, as

Na_2CO_3 , on exposure to the air, this ferrous carbonate decomposes into free CO_2 , and Fe_2O_3 ; the latter substance is known as "jeweler's rouge" (polishing powder), and as the pigment, "Venitian red." All ferrous compounds are prone thus, to take up oxygen from the air, and become changed into *ferric* compounds, which are chiefly, either red or yellow.

Ferric oxide, Fe_2O_3 , sesqui oxide of iron, may be considered the basis of the *ferric* salts. The oxide itself has been sufficiently described.

Ferric Chloride, Fe_2Cl_6 , perchloride of iron, can be prepared by dissolving ferric oxide in hydrochloric acid, or by direct action of Cl on iron, or by heating the hydrate in the presence of Cl . It consists of orange red, deliquescent crystals, of strong styptic taste, and acid reaction, and very soluble in water and alcohol.

Ferric hydrate, $\text{Fe}_2(\text{HO})_6$, hydrated peroxide of iron, is obtained as a reddish precipitate, when either ferric chloride or ferric sulphate, in solution, is added to solution of ammonia (or caustic alkalies). It is the favorite antidote to arsenic; should be made fresh, washed in water, and given *ad libitum*. Iron rust, is ferric hydrate.

Ferric sulphate, FeS_2 , iron pyrites, sometimes
ite

called "fools gold," is used in the manufacture of copperas and of sulphuric acid.

Ferric sulphate, $\text{Fe}_2(\text{SO}_4)_3$, persulphate of iron, prepared by boiling a solution of ferrous sulphate and sulphuric acid, and adding nitric acid. On evaporation it appears as a buff-colored mass, slowly soluble in water. Practically, however, the above solution is *not* evaporated; it is a clear brownish-red liquid, of slight odor, very styptic, and of somewhat sour acid taste.

Monse's solution, subsulphate of iron solution, an oxy-sulphate, probably $2\text{Fe}_2\text{O}_3, (\text{SO}_4)_3$. The solution is prepared as above, except that only one-half the amount of sulphuric acid is employed. It is of a deep ruby red color, no odor, and of a very astringent but not acid taste. *Monse's powder* of the subsulphate, possesses the same properties as the solution.

Magnetic iron oxide, $\text{FeO}, \text{Fe}_2\text{O}_3$, ferroso-ferric oxide, is incidentally produced in the shops in the form of "iron-scales."

Dyalized iron is essentially an aqueous solution of the hydrate obtained from a mixture of ferric chloride and ammonia; the ammonium chloride formed, passes through *the dialyzer*, leaving the iron in a *colloid* state. It is inodorous; of a non-styptic taste, and considered by some a good chalybeate.

Iron by hydrogen, reduced iron, metallic iron in fine powder, gray-black in color, produced by passing a stream of hydrogen over heated ferric oxide.

MATERIA MEDICA.—Salts of iron, combined with vegetable astringents, form *ink*. They are, therefore, incompatible with *tannin*.

The per-(ferric) salts of iron have a decided local influence in arresting passive hemorrhage, their astringency causing contraction of the small vessels; and by coagulating their albumen, a corrugating and hardening of the tissues.

Whenever it becomes advisable to use a hæmostatic after the extraction of teeth, either the *perchloride* in semi-crystallized form, or in solution; or the *liquor ferri chloride* (ferric chloride crystals, 37.8 per cent, in water), or *Monsels powder* or *solution* may be selected for the purpose, and applied with a prospect of more than average success. We would not recommend these salts of iron, however, in gargles or washes for mouth or throat, inasmuch as they undoubtedly corrode the teeth.

The principal indication for the internal exhibition of iron, is as a *tonic* in *anæmia*. Iron being an essential constituent of the red corpuscles of the blood, it not only augments the *quantity* of haemoglobin, but increases the *number* of the red corpuscles as well; furnishing thus, by an extra supply

of healthy blood, fresh stimulus to the muscular fibers of the heart. It tones up the mucous membrane of the stomach, inducing improved appetite and digestive power. It increases the temperature by reason of its function of carrying oxygen to the tissues.

CHAPTER XIV.

IRON—*Continued.*

The actual state in which iron exists in the red corpuscles, and the exact relation it bears to the operations in tissue waste, are not definitely known. We may assume, however, with some degree of safety, that when it takes up, in the lungs, the oxygen, received from the air, by inhalation, the chemical state, in which it passes through the arterial circulation to the capillaries, is as ferric oxide (Fe_2O_3). In the process of tissue waste, some, perhaps many, of the molecules of this compound are reduced to ferrous oxide (FeO), thereby setting free *nascent* oxygen, which at once plays its part by uniting with the carbon (and other elements also), of the tissues, which union produces CO_2 . Now, CO_2 does not long remain free; it finds the reduced iron oxide, and *they* unite, producing ferrous carbonate, according to the simple equation, $\text{FeO} + \text{Co}_2 = \text{FeCO}_3$.

The ferrous carbonate, thus formed, is carried through the *venous* circulation to the capillaries of the lungs, where *it* suffers decomposition by the in-

fluence of the inspired oxygen of the air; the CO_2 escaping in the respiratory exhalation, while the FeO takes up with the oxygen present, $2\text{FeO} + \text{O} = \text{Fe}_2\text{O}_3$.

Such, in brief, are probably the principal reactions, involving iron, that occur throughout the circulation. They afford us a fair idea of at least two important functions performed by iron, namely, the carrying of atmospheric oxygen from the lungs to the capillaries, via the arterial circulation; and of the carbon dioxide, by way of the veins, from the capillaries to the lungs.

A question of some import occurs in this connection. Does the CO_2 , formed continuously in every portion of the living animal body, have any influence at the time of its development, in preventing the *oxygen of reserve* from a too active participation in the oxidation of the tissues? And does its presence, while yet free, previous to its union with FeO , tend to keep the normal process of oxidation of tissues from being painfully manifest to our consciousness, by governing, with just the exact amount of pressure required, the conductivity of the peripheral extremities of the sensory nerves, or by primary influence, through the same direct means, on the receptive centers of the brain itself?

If CO_2 is possessed of the attributes indicated, then any increase for the time being, in the amount produced, or any means that will prevent, even temporarily, the regularity of its removal from the body, will induce a corresponding reduction in our perception of pain. Rapid breathing, "holding the breath," experimentally, or as we do instinctively, while awaiting a shock, violent exercise, and mental excitement, are all productive of either an increase in the quantity of CO_2 , or of its temporary retention throughout the tissues; and we all recognize, as a fact, that the above means are effective for the time being, in lessening our susceptibility to pain. Cause and effect seem, in these instances, to agree.

Physical causes—molecular physics—although they may not be appreciable to our senses, are involved in all forms, *plus* or *minus*, of nervous or mental phenomena, including the so-called hypnotic influence; but in explaining the physiological action of certain drugs, we are frequently compelled to dismiss the subject by saying, "they have a direct effect on the nervous system," or some particular set of nerves.

In all experiments with *nitrous oxide*, it has been found to be active only as a carrier of oxygen. Combustibles burn in it with more energy

than in the air, the heat setting the oxygen free, *oxide compounds* only resulting. It has also been ascertained, that when inhaled, N_2O dissolves in the arterial blood, unchanged. In this way it supersedes the legitimate carrier of oxygen, Fe_2O_3 , and the latter compound, not being allowed to decompose, in the capillaries, into ferrous oxide, FeO , the CO_2 that is formed, in much greater abundance than usual, by the oxygen of the N_2O , can not escape in the usual way, as ferrous carbonate; much of it, comparatively, remains free, for the time being, causing at first, the pleasurable excitement, exaltation of the faculties, hallucination, *anæsthesia*, and finally a state of *carbon dioxide asphyxiation*, which are observed to take place when N_2O is inhaled.

Nitrous oxide is, therefore, not an asphyxiating agent *per se*. It so acts indirectly, only when pushed to the extent of developing and accumulating CO_2 , in quantity necessary for the purpose, the danger line moving to and fro, according to the individual. The relative immunity from danger, with N_2O as an anæsthetic, may be accounted for by the exaggerated oxidation of carbon (a natural process), which immediately ensues; and the rapid escape of the active compound, CO_2 , as soon as air is admitted, which at once restores to iron the

opportunity of performing its accustomed duties in the circulation.

MANGANESE.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Mn.	54.	8.	II, IV, VI.

Manganese is closely related to iron. It occurs somewhat abundantly, mainly as an oxide, MnO_2 , which ore, when ground, is known as the black oxide of manganese.

The metal is chiefly obtained from the black oxide, by reduction with carbon. It is gray-white, lusterless, resembling cast iron, brittle and very hard, very difficult to melt, and decomposes water, setting hydrogen free. With copper it forms a beautiful alloy.

Four well defined oxides, MnO , MnO_2 , Mn_2O_3 , and Mn_3O_4 , are known. The first is strongly basic, the third is weakly basic, forming, with acids, typical salts, and with basic oxides it acts as acid, forming salts called manganites. The second and fourth oxides are neutral.

Hydrogen permanganate, $\text{H}_2\text{Mn}_2\text{O}_8$, permanganic acid, produced by distilling potassium permanganate with sulphuric acid, is a most powerful oxidizer, setting fire to alcohol, paper, etc. Its most characteristic salt is *potassium permanganate*,

$K_2Mn_2O_8$, prepared by mixing manganese dioxide, potassium chlorate and potassium hydrate in a little water, evaporating and heating to red heat. It presents, as dark violet crystals, soluble in water, the dilute solution, exhibiting a superb purple color. It readily parts with its oxygen in the presence of organic matter, as alluded to under potassium.

COBALT, NICKEL.

Co. Ni.

Both cobalt and nickel are closely related to iron, but are comparatively rare. The atomic weight of cobalt is 59, of nickel, 58, and of iron, 56. The specific gravities of these three metals are also about the same, and their valency is the same.

COBALT occurs in nature as a sulphide, Co_3S_4 ; as an arsenide, Co_2As_6 ; as an arsenate, $Co_3(AsO_4)_2 \cdot 8H_2O$; as speiss-cobalt, $CoNiFeAs_2$; and as cobalt-glance, $CoFe(AsS)_2$. Many of the compounds of cobalt are used as pigments and for coloring porcelain and glass. A solution of cobaltous chloride, $CoCl_2$, in water, furnishes *sympathetic ink* of a blue color, when *heated*, but which becomes invisible on cooling, by absorption of moisture.

NICKEL is always a constituent of meteoric iron.

Its chief sources are, as the arsenide, kupfernickel, a yellow ore, whence its name; and as sulphides and silicates of nickel. The metal is used somewhat extensively for coating other metals by electrolysis, the electrolyte employed being the double sulphate of nickel and ammonium $(\text{NH}_4)_2\text{Ni}(\text{SO}_4)_2$, $6\text{H}_2\text{O}$, dissolved in water. The lower salts of nickel are generally green. An alloy of nickel and copper is the familiar instance of the "nickel." German silver is nickel, copper, and zinc.

Like iron, both cobalt and nickel are magnetic. They are also malleable and ductile, and occupy the first rank in tenacity, like iron, and are affected by acids similarly to iron. The color of cobalt is reddish-white.

CHAPTER XV.

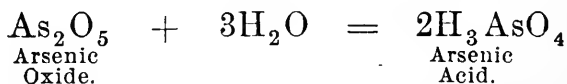
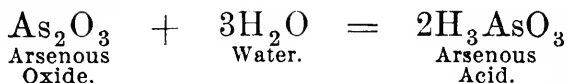
ARSENIC.

Symbol,	At. Wt.	Sp. Gr.	Valency,
As.	75.	5.7.	III-V.

Elementary arsenic is inert, but its soluble compounds are extremely poisonous. It is found free, and in a great many minerals, in company with sulphur, iron, cobalt, nickel, etc., as sulphides, arsenides, arsenites, and arsenates. It is chiefly obtained, however, from arseno-pyrites, a sulphide of iron and arsenic, by sublimation, the arsenic being volatile. Its vapor has an odor of garlic, by which its presence may be indicated, when heated by the blow pipe. Like phosphorus, its molecule consists of four atoms, $\begin{array}{c} \text{As} \equiv \text{As} \\ \text{As} \equiv \text{As} \end{array}$ inasmuch as its vapor density is 150. Arsenic is a dark-gray, brittle solid, metallic in appearance; classed by some as a non-metal, by others as a metal; it is about midway, in chemical properties, between these two classes of elements. About the only purpose for which metallic arsenic is used, is for hardening lead "shot." A very impure variety is sold as a

fly-poison, under the erroneous name of "cobalt." "Marsh's test" for arsenic, consists in the development of "nascent" hydrogen, in the presence of the suspected mixture. Pure zinc and dilute hydrochloric acid will accomplish this, and if arsenic is present, it will escape as *arsine*, AsH_3 , an exceedingly poisonous gas, one bubble of which proved fatal to its discoverer, Gehlen. This gas, as it escapes from a jet, arranged with proper precaution, when kindled, will deposit a mirror-like stain of metallic, As on a cold, clean surface of porcelain, held in the flame. Antimony compounds will give similar results, forming SbH_3 , but the deposited arsenic is soluble in sodium hypochlorite solution, whereas the antimony is not. It is said that $\frac{1}{5000}$ of a grain of arsenic can be detected in this way.

Two oxides of arsenic, and their corresponding acids are known.



Arsenic compounds are not so poisonous as the *arsenous*, and not so important.

Arsenous oxide, As_2O_3 , exhibits such momentous qualities, that it has appropriated the very *name* of *arsenic*, and is generally known as such. It is

formed by roasting arsenical ores in air, collecting the vapors and resubliming; it exists in two varieties, one crystalline, and the other in lumps, resembling porcelain; the latter is the usual commercial variety, the powder being white and heavy, of a gritty feel, tasteless, and odorless, and unchanged in air. It is slowly soluble in water, giving rise to arsenous *acid*, whose salts are known as arsenites. The arsenites of the alkali metals are soluble in water; the arsenites of iron and magnesium not so, hence the employment of iron and magnesium hydrates, as antidotes. Sodium arsenite Na_3As , as a mordant is used in calico printing; and the brilliant pigment, Paris-green, a double salt of copper arsenite and copper acetate, $\text{Cu}_3\text{As}_2 \text{ Cu} (\text{C}_2\text{H}_3\text{O}_2)_2$ is extensively used for coloring wall-papers. Whenever such paper gives a green color to flame, or changes from green to blue, by a drop of aqua ammonia, the presence of arsenic may be suspected.

Dissolved in acids, arsenous oxide forms salts, typical of the acid; as, for instance, from hydrochloric acid solution, *arsenous chloride*, AsCl_3 , is obtained.

The 2 *sulphides of arsenic*, As_2S_2 , As_2S_3 , are known as the minerals, red *realgar*, and golden-yellow *orpiment*, respectively.

MATERIA MEDICA.—The official name of arsenous oxide, As_2O_3 , is *Acidum Arsenosum*, but it is commonly spoken and written of as *arsenic*; also, as arsenous anhydride, arsenious acid, white oxide of arsenic, white arsenic, arseniosum oxidum, and ratsbane; in its medicinal consideration, we shall follow the custom, and call it *arsenic*.

When applied locally, arsenic acts as a severe caustic irritant, inducing redness and excessive inflammation of the part, followed by suppuration and sloughing; for this reason, it is used sometimes, as a cancer cure. In the operation of devitalizing exposed dental pulps, it is the Samson upon which nearly all dentists confidently rely. The amount of arsenic necessary to destroy the life of the pulp need never exceed the ordinary internal dose. It is usually mixed with some preparation of morphine, or cocaine, of which mixture a paste with either creosote, carbolic acid, or oil of cloves, etc., is made and applied to the pulp, and sealed with gutta-percha, or cotton dipped in either sandorac varnish, or in a saturated solution of aristol in chloroform.

A suggestive method that might decrease the period of pain, would be to apply a trace of powdered cocaine hydrochloride, say for five minutes, before inserting a paste, made of arsenic and solid

caustic potash. Sometimes tannin alone, or in glycerine, is employed as an *adjuvans* to arsenic, on account of astringent properties. In all cases care must be observed, lest a part of the arsenic escape to the surrounding parts, inasmuch as the *arsenic burn* is painful and slow to cure, and the alveolar process itself might be, to a limited extent, completely destroyed. Certain individuals are peculiarly susceptible to the injurious effects of arsenic, and these do not suffer in having pulps devitalized, as do those who have strong resisting power against the action of the drug.

Taken internally in small doses, arsenic acts as a tonic, and antiperiodic, increasing appetite and digestion, producing a rotund form, and fair skin; increasing the secretions of the *primæ viæ*, exalting the mental faculties and stimulating the heart's action, and respiratory power. It is recommended in treatment of ague, neuralgia, asthma, dyspepsia, chronic skin affections, etc. When its use is continued for some time, it usually causes œdema of the eyelids, ptyalism, disordered systemic condition, and eruptions of the skin. The arsenic eaters of Styria observe the precaution of not taking water into the stomach at the same time they partake of the drug, so that its slow absorption, and probably, rapid elimination follow. Toxic doses produce gas-

tro-enteritis, vomiting, diarrhœa, etc. In chronic poisoning, there is in addition, a fatty degeneration of the muscles and heart, and parenchymatous degeneration of the liver and kidneys.

Arsenic is usually given in the form of Fowler's Solution, *Liquor potassii arsenitis*, prepared by boiling together arsenous oxide and potassium bicarbonate in water, to which the compound tincture of lavender is added. This preparation may be taken in water, always after meals, full doses at first, gradually diminishing as the treatment proceeds.

Antidote.—Emetics (zinc sulphate), followed by freshly prepared hydrated iron (see Iron), and castor oil.

Dose.—*Liquor Potassii Arsenitis*, 0.10–0.30 fGm. (℥ ij–v).

“ *Acidum Arsenosum*, 0.001–0.006 Gm. (gr. $\frac{1}{64}$, $\frac{1}{10}$).

R. *Acidi Arseniosi*, 8.00 Gm (ʒij).

Cocaini Hydrochloris, 2.00 Gm. (ʒss).

M. S. For office use.

To prepare for devitalizing pulp, make a paste with caustic potash and carbolic acid. (Robinson's Remedy.)

ANTIMONY.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Sb.	120	6.7	III—V.

Antimony is not an abundant metal, although

comparatively inexpensive. It exists in nature free, and as an oxide, a sulphide, and with silver and sulphur. The metal may be obtained by heating its sulphide with iron, $\text{Sb}_2\text{S}_3 + \text{Fe}_3 = 3\text{FeS} + 2\text{Sb}$; or by roasting its sulphide, it is converted into an oxide, which is reduced by carbon.

Antimony is a blue-white solid, hard and very brittle; does not tarnish in the air, but takes fire at a red heat; is soluble in nitric acid, and forms synthetic binary compounds, with chlorine, oxygen, bromine and iodine. Zinc precipitates antimony from its solutions, as a black powder, which is used for giving plaster casts the appearance of steel. The metal melts at 450 (840F). A curious allotropic variety is obtained by electrolysis, which is explosive when hammered or heated. The chief use of the metal is in giving hardness to alloys. Typemetal is an alloy of antimony, lead, and tin; Britannia metal, of antimony and tin: and Babbitt's anti-friction metal, useful for dies, is composed of antimony, lead, tin, and copper.

Antimony forms three oxides Sb_2O_3 , Sb_2O_4 , Sb_2O_5 . The trioxide and pentoxide, like those of nitrogen are acid oxides, but their acids HSbO_2 , HSbO_3 , unlike those of nitrogen, are very weak. There is also an ortho-antimonic acid, H_5SbO_5 , and an ortho-antimonous acid, H_3SbO_3 .

Antimony and potassium tartrate, is a salt known as "tartar-emetic."

Antimonous chloride, SbCl_3 , is the "butter of antimony," which is changed by water, into an oxychloride, $\text{SbCl}_3 + \text{H}_2\text{O} = 2\text{HCl} + \text{SbOCl}$.

Antimony oxysulphide, $\text{Sb}_2\text{O}_2\text{S}_2$, imparts a yellow tint to glass and porcelain. The nature of H_3Sb was sufficiently indicated in the preceding chapter.

CHAPTER XVI.

BISMUTH.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Bi.	208.	9.80.	III-V.

BISMUTH, like antimony, belongs to the same class with arsenic. It is principally found native, and is obtained by simply melting out the metal from adherent rocky matter and collecting in suitable molds. It is comparatively rare, and besides its native condition, is found in only a few minerals, as an oxide, a sulphide, a sulpho-telluride, and a carbonate.

It is a brilliant reddish-white, hard brittle metal; crystallizes in rhombohedrons, which, on account of slight tarnishing in the air, present an iridescent appearance. It is acted on readily by nitric and nitro-hydrochloric acids, and by chlorine, but not by hydrochloric or cold sulphuric acids. It melts at 264° (507°F), and in solidifying, expands $\frac{1}{31}$ of its bulk, making a sharply defined cast when poured into a mold.

Bismuth is important chiefly as a constituent of fusible alloys, one of which was described in a pre-

vious chapter. Another is composed of 3 parts of cadmium, 4 of tin, 8 of lead, and 15 of bismuth, which melts as low as 60° (140°F); and another, which melts at 82° (180°F), is composed of 1 of cadmium, 6 of lead, and 7 of bismuth. Other alloys, of the above kind, serve as safety plugs for steam boilers, vulcanizers, etc.

In most of its compounds bismuth acts as a trivalent base, such as the chloride, BiCl_3 ; the oxide, Bi_2O_3 ; the sulphate, $\text{Bi}_2(\text{SO}_4)_3$, and the nitrate, $\text{Bi}(\text{NO}_3)_3$. When water is added in excess to a solution of a bismuth salt, the bismuth salt decomposes, a basic salt being precipitated.

The formation of bismuth sub-nitrate, $\text{H}_2\text{BiO}_2\text{NO}_3$, by dissolving bismuth in nitric acid, depends on this principle, although the process itself is rather complicated.

When water is added to bismuth chloride, BiCl_3 , a white precipitate of bismuth oxycchloride results. $\text{BiCl}_3 + \text{H}_2\text{O} = 2\text{HCl} + \text{BiOCl}$. This latter substance is a white soft bulky powder, resembling the sub-nitrate, and is used as a "face powder." The following equation, $\text{BiCl}_3 + 3\text{KOH} = 3\text{KCl} + \text{Bi}(\text{OH})_3$, shows the formation of *bismuth hydrate*, a precipitate which, on drying, loses water, and becomes an amorphous white flocculent powder, less unwholesome to the skin

than the oxychloride. This *hydrated oxide*, $\text{BiO}(\text{HO})$, is *basic* to strong acids, as sulphuric, etc., and *acid* to strong bases, as sodium, etc.; for example, NaBiO_2 , *sodium bismuthate*.

MATERIA MEDICA.—*Bismuthi sub-nitras* is employed locally, in powder, alone, or with charcoal, in *cancrem oris*, and other forms of ulceration of the mouth, in *intertrigo*, and as a snuff in inflammation of Schneiderian membrane, etc. It possesses astringent, sedative, and antiseptic properties, in virtue of which, it probably acts internally in relieving gastric pains, vomiting, and diarrhœa.

Dose.—0.50—1.00 Gm. (gr. viij—xv.)

VANADIUM.

Symbol,	At. Wt.	Sp. Gr.	Valency,
V.	51.	3.6.	V.

VANADIUM is an extremely rare substance; it occurs in small quantity in some iron, lead, and copper ores, and is a non-volatile gray-white powder. It forms 5 oxides corresponding to those of nitrogen, V_2O , V_2O_2 , V_2O_3 , V_2O_4 , and V_2O_5 . Vanadium compounds have very little practical importance.

TANTALUM AND NIOBIUM.

Ta.	At. Wt.	Nb.	Valency,
	182.	94.	V.

These so-called metals are very rare. Both are

are black powders. They form acid oxides. Niobium is also known by the better name, *Columbium*.

MOLYBDENUM, TUNGSTEN.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Mo.	96	8.6	VI.

MOLYBDENUM is another rare element, occurring in small quantity, as a sulphide, MoS_2 , and as lead *molybdenate*. It is a white, brittle metal, almost absolutely infusible. When heated in air, it oxidizes to *molybdic oxide*, MoO_3 , analogous to sulphuric oxide, SO_3 ; *molybdic acid*, H_2MoO_4 , is analogous to sulphuric acid, H_2SO_4 . Some of the molybdenum compounds are indispensable reagents.

TUNGSTEN.

Symbol,	At. Wt.	Sp. Gr.	Valency,
W (Wolfram),	184.	19.26.	VI.

TUNGSTEN is not abundant, but more so than molybdenum. It is found as ferrous tungstate, FeWO_4 , in the mineral *wolfram*, and as calcium tungstate, and lead tungstate. It is a white metal, hard and brittle, and very heavy, hence its name, signifying *heavy stone*; it is difficult to fuse, and when heated to redness takes fire, and produces tungstic oxide, WO_3 . A small addition of tungsten to steel, is said to confer on the latter, extraordinary hardness and fineness.

The oxide, WO_3 , is an acid oxide, the corresponding acid having the formula, H_2WO_4 . The tungstate of the alkali metals (more especially of sodium, Na_2WO_4), are sometimes used as mordants, and for rendering light cloth fabrics unflammable.

URANIUM.

Symbol,	At. Wt.	Sp. Gr.	Valency,
U.	2.39.	18.68.	VI.

URANIUM is another rare metal, existing in only a few minerals; it is found mainly in the form of an oxide.

When fused, which is difficult to accomplish, it is a white malleable metal, permanent in air, but if pulverized, and heated to about 200° (392°F), it takes fire, and burns with great splendor, producing a green oxide. It also shows great energy in uniting with chlorine and sulphur.

Uranium forms several oxides, which are *basic* in the presence of strong acids, and *acid* in the presence of strong bases, like those of tungsten. It is quadrivalent in the *uranous* compounds, as UCl_4 , UO_2 , $\text{U}(\text{SO}_4)_2$, etc., and sexvalent in the *uranic* compounds. In the uranic salts the bivalent radical uranyl, UO_2 , is supposed to be the electro-positive radical, as in uranic oxide (uranyl oxide), $(\text{UO}_2)\text{O}$; also $(\text{UO}_2)\text{Cl}_2$, $(\text{UO}_2)_2\text{NO}_3$, $(\text{UO}_2)\text{SO}_4$.

There is no *uranic* chloride (UCl_6), or bromide, etc., as with tungsten.

Alkaline bases form salts with uranic oxide, UO_3 , known as *uranates*; thus, Sodium Uranate, Na_2O , 2UO_3 , and Ammonium Uranate, Am_2O , 2UO_3 , which are known as "uranium yellow," are used in coloring porcelain and glass, conferring a green-yellow color.

CHROMIUM.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Cr.	52.	6.81.	VI.

CHROMIUM occurs somewhat more abundantly than the other metals of the chromium group. It occurs as lead *chromate*, and also in small proportion in several minerals, but is obtained usually from ferrous *chromite*, FeCr_2O_4 .

Chromium, obtained by reducing its oxide by carbon, exhibits as a very hard, steel-gray mass, practically infusible; obtained by reducing the chloride by zinc, it occurs as a glistening gray-green powder, showing minute tetragonal octahedrons. It is unaffected in air, but burns, when heated in oxygen. It has been found in meteoric iron. It is readily acted upon by dilute hydrochloric acid, less so by dilute sulphuric acid, and not at all by concentrated nitric acid. The metal itself is of no practical use, but its compounds are

both numerous and important; they are nearly all brilliant in colors, whence the name of the element, taken from a Greek word, signifying *color*.

Chromous chloride, CrCl_2 , is one of the most powerful reducing agents known. It precipitates gold from solution of auric chloride.

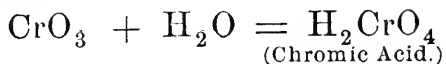
Chromic Chloride, Cr_2Cl_6 , occurs in crystalline plates of a pale violet color. Its *hydrate*, $\text{Cr}_2\text{Cl}_6 \cdot 9\text{H}_2\text{O}$, is a dark green.

Chromous oxide, CrO , is a strong base, forming salts of a pale blue, but unstable, as they rapidly absorb oxygen from the air.

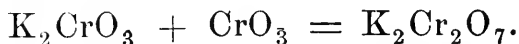
Chromic oxide, sesquioxide, Cr_2O_3 , is a *bright green powder*. It is used in giving a green color to porcelain and glass, and to modify the yellow of titanium oxide in porcelain teeth. The emerald owes its color to this compound. It is *basic* or *acid*, according to the presence of acid or basic radicals.

Chromium trioxide, CrO_3 , may be obtained in superb crimson needles, by adding strong sulphuric acid carefully to a saturated aqueous solution of potassium bichromate, allowing the mixture to cool, and drying on a porous tile. It is a powerful oxidizing substance. A drop of alcohol coming in contact with the dry crystal, will ignite by the heat of the oxidation.

Chromic trioxide is the typical acid oxide of chromic acid and the chromates.



With potassium, for example, it forms the normal salt, K_2CrO_4 , and by addition to this, of one more molecule of CrO_3 , we have potassium pyrochromate or dichromate.



This salt is better known as *bi-chromate of potash*. It occurs in splendid orange-red crystals, and is employed in the arts for various purposes; in preparing the chromium paints, in dying, in calico printing, and in photography. Gelatin containing the salt, remains insoluble wherever acted on by light, but is soluble in other portions: the photograph taken on such a film of gelatin stands out in bold relief, and can be copied in electrotpe. This salt is also used in certain galvanic battery solutions.

By adding two molecules of $2(\text{CrO}_3)$ to K_2CrO_4 , we have $\text{K}_2\text{Cr}_3\text{O}_{10}$.

Plumbum chromate, PbCrO_4 , is "chrome yellow," which, by boiling with caustic alkali is converted into $\text{PbCrO}_4, \text{PbO}$, "chrome red;" and "chrome orange" is a mixture of these, the orange ray being intermediate between yellow and red.

MATERIA MEDICA.—Chromic acid is one of the most energetic disinfectants, in virtue of oxidizing power. It should not be mixed with organic substances. As an escharotic it penetrates deeply, and whenever used in the mouth, in treatment of phagedænic ulcers, etc., it should be in suitable dilution, and very carefully applied.

CHAPTER XVII.

GOLD, ETC.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Au.	96.5.	19-4.	I-III.

GOLD, *aurum*; the alchemistic “Rex Metallorum,” has held its supremacy among the metals from the earliest historic times. It occurs native, and though very widely diffused, is not found in “paying” quantities outside of a few limited sections, as in Australia, and the gold fields of the United States.

The association of gold in nature, is generally with quartz, iron oxide, in the debris or alluvial deposits of such rocks, and in the sands of various rivers. The only exception to its otherwise universal existence in the metallic state, is as a *telluride*, which also contains silver and other tellurides. Alluvial gold is obtained by washing, which separates the metal from the earthy matter. When a vein-stone is worked for gold, it is crushed to powder, and if it contains pyrites, it is roasted; it is then agitated with mercury, which takes up the gold by amalgamation. The mercury is separated

from the gold by pressure and distillation, and is recovered for future use. If traces of base metals are present, the gold is refined by passing chlorine gas through the melted metal. By *quartation*, it is separated from silver; the operation consisting of adding silver to the bullion, until the latter is made up of three parts of silver and one of gold. The alloy is rolled into thin ribbon, and then the silver in it dissolved out by nitric acid.

Gold possesses considerable tenacity, and ranks first in malleability and ductility; it is soft, and crystallizes in isometric forms; its color is brilliant orange-yellow, by reflected light; and when beaten into very thin leaves, shows a bright green, by transmitted light. It melts at about 1100° (2012°F.)

Gold is always alloyed with other metals, to give it the required hardness for practical use in the arts, except in the case of preparations of gold for filling cavities in teeth, wherein absolute purity is desirable.

Pure gold is 24 *carats* fine. The mint alloy of the United States is 22 carats; that is, 9 parts of gold and 1 part of copper. Jewelers' gold is of a less carat, ranging downward from 18 to 12 carats. Copper confers a ruddy tint to the alloy, and silver a paler color. Platinum, or palladium, like Ag., gives to gold a lighter shade; the alloy, with small

proportions of platinum, is hard and elastic; with palladium, hard and brittle. Traces of such metals as antimony, tin, arsenic, bismuth, lead, etc., impair the malleability and ductility of gold, and render it intractable.

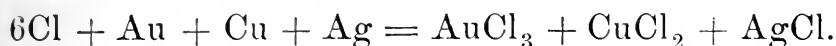
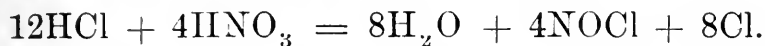
Dentists' gold foil, presumed to approximate 24 carats, is obtained by successive annealings and hammering of the ingot, until thin enough to pass between the rollers of a flatting mill. The thin ribbons of gold thus prepared are cut into small squares, and these are piled in considerable number between pieces of vellum and parchment, and beaten; again cut into squares, and beaten; and finally hammered between "gold beater's" skins, until the required foil *number* is obtained.

Gold is practically unaffected by the air, sulphuretted hydrogen, the alkalies, or any single acid, except, slightly, by selenic acid. It yields readily, however, to nascent chlorine, a gentle heat favoring the rapidity of the combination.

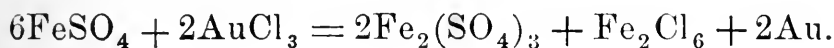
The chlorine for the purpose, is usually produced by mixing 3 parts of hydrochloric acid with 1 part of nitric acid, the mixture being known as *aqua regia*, alluded to in a previous chapter.

To obtain free gold from its alloy with copper, and silver, or other metals, or either one alone, dis-

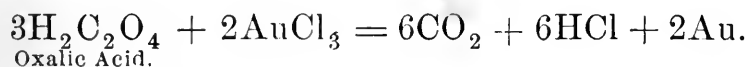
solve the alloy in aqua regia, facilitated by a gentle heat. The reaction will be as follows:



The silver chloride falls down as a white curdy precipitate, and the chlorides of gold and copper remain in solution; it now remains to precipitate the gold, and leave the copper in solution. This is accomplished by various reagents, of which, two only need be mentioned, namely, solutions of ferrous sulphate (copperas), and oxalic acid. The ferrous sulphate is changed into ferric compounds, and the oxalic acid into carbon dioxide, and hydrochloric acid, thus:



or,



The gold precipitated by the ferrous sulphate, occurs as a dirty-looking brown powder; that by oxalic acid, as spongy or crystalline. The precipitate is washed, placed in a crucible lined with borax, melted, and poured into proper ingot.

Scraps, filings, and sweepings of gold alloys containing more or less of *baser* metals, as zinc, tin, lead, antimony, bismuth, iron, etc., are often refined by the *dry method* or roasting process, which consists of adding to the heated mass, either oxidizing,

chloridizing, or sulphidizing substances. Niter, (KNO_3), is rich in oxygen, which it readily gives up when heated. It is, therefore, the substance usually employed as the oxidizer, and to whose power all the baser metals named, except tin, cheerfully submit. The latter metal, however, is easily chloridized by heating with mercuric chloride (HgCl_2). When sulphur is needed in the process, it is furnished by the crude antimonium sulphide (Sb_2S_3). The disengaged sulphur forms *sulphides* of the base metals present; the antimony alloys with the gold, and is afterward driven off from the latter, by heating in an excess of air.

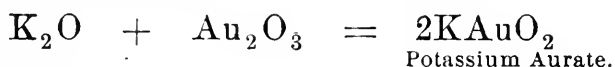
The chemical compounds of gold are neither numerous nor important.

Auric chloride, AuCl_3 , resulting by dissolving gold in aqua regia and evaporating the solution over the water bath, occurs as deliquescent, dark red crystals, soluble in water, ether, and alcohol; of a styptic taste and escharotic and disinfectant properties, the latter effect being due to the ease with which it decomposes. It forms yellow double chlorides, with the chlorides of sodium, potassium and ammonium, as NaCl , AuCl_3 , called *sodio-chloraurate*.

Aurous chloride, AuCl , is obtained as a yellow-white substance, by heating evaporated auric chlo-

ride. It is insoluble in water, and tends to change to free gold and auric chloride.

Auric oxide, Au_2O_3 , is produced by digesting magnesia, MgO , in auric chloride. The magnesium aurate that is formed, is decomposed by nitric acid, and on drying the residue, auric oxide is found as a dark brown powder, easily decomposed by light and heat. It acts generally as an acid oxide, uniting with bases to form *aurates* thus



Ammonium aurate, obtained by digesting auric oxide in ammonia, is known as fulminating gold, a dangerous explosive, $\text{NH}_4, \text{AuO}_2$.

Aurous oxide, Au_2O , is a greenish powder. *Purple of Cassius* is probably a compound of this oxide, with the two oxides of tin, obtained by reaction between auric chloride and the two chlorides of tin, produced by dissolving gold and tin in aqua regia, and adding a weak solution of tin in hydrochloric acid. Chloridation and oxidation of both metals take place successively. "Purple of Cassius" ($\text{Au}_2\text{OSn}_3\text{O}_5$), as before mentioned, is used in coloring porcelain.

MATERIA MEDICA.—The mono-(aurous) chloride is not used in medicine. The tri-(auric) chloride is sometimes employed in obtunding sensitive dentine dissolved in ether or alcohol. It acts like the

chloride of zinc, by *dehydrating* the gelatinous constituent of the dentine.

For internal administration the trichloride is usually combined with sodium chloride. It produces an exhilarating influence on the nervous system, and is useful in hypochondriasis, functional impotence, etc., and in treating syphilis, as a substitute for corrosive sublimate. Its antidote is the same as for the latter drug. The so-called *bi-chloride* of gold cure mixture for alcoholism and the opium habit, is said to contain no gold whatever, and is not regarded as belonging to legitimate therapeutics.

Dose. Auric chloride, 0.001–0.003 Gm. (gr. $\frac{1}{64}$ – $\frac{1}{20}$).

Professor Grant Molyneux, of Cincinnati, has recently succeeded in developing a process of gilding porcelain teeth with gold, to represent fillings, facings, etc. The process consists essentially of compounding neutral auric chloride (AuCl_3), with Venice turpentine, and thinning the mixture with Artist's Dresden "thick oil," to the proper consistency. This is spread in desired position on the porcelain, and allowed to dry slowly over a water bath. It is then subjected to a red heat and, on cooling, leaves a pure gold surface, susceptible of a fine polish.

A similar process with neutral platinic chloride,

(PtCl_4), instead of gold solution, has been found by Professor M. to be effective in forming a surface of *platinum*, as a successful *backing* on porcelain teeth, to which gold can be soldered without the usual intervention of platinum pins, making an attachment thus, as strong as the porcelain itself.

PLATINUM.

Symbol,	At. Wt.	Sp. Gr.	Valency,
Pt.	197.	21.5.	II-IV.

PLATINUM, originally found in South America, is now principally supplied from the Ural Mountains and, to some extent, from Borneo and California.

It always occurs in the metallic state, in little grains or lumps, generally alloyed with gold, copper, and iron; and its natural congeners of the platinum group, such as iridium, osmium, etc.

The methods employed for separating pure platinum from its ores are complicated. It is a blue-white metal, less brilliant than silver; not affected by the air, nor by any single acid. It combines directly with sulphur, silicon, arsenic, phosphorus, and chlorine; is acted upon by fused caustic hydrates, and dissolves slowly in aqua regia. It is malleable and ductile; is possessed of considerable tenacity; is about as hard as copper, expands uniformly with glass or porcelain, and is relatively a

poor conductor of heat and electricity: it melts at the temperature of the oxyhydrogen flame.

On account of its infusibility, and insolubility in acids, platinum is used in various forms in the chemical laboratory, such as dishes, crucibles, stills, foils, wire, blow-pipe tips, etc.; also in the construction of incandescent electric light lamps, as the negative element in Grove's galvanic battery, as sustaining pins in porcelain teeth, as a basis for continuous gum plates, and in combination with felspar, in giving a required shade to enamel. In the form of platinum-foil, sponge, or better still, *platinum black*, it possesses, in a high degree, the power of condensing gases on its surface, the latter being able to condense 800 times its own volume of oxygen.

Platinum compounds are numerous and somewhat interesting.

Platinic Chloride, PtCl_4 , is formed whenever platinum is dissolved in aqua regia; on evaporation it shows as a deliquescent red-brown substance, soluble in water, alcohol and ether; it is used in chemical analysis in detecting alkaloidal bases, as *ptomaines*, etc. It unites with the alkali chlorides to form *chloroplatinates*, as $2\text{KCl}, \text{PtCl}_4$.

Platinous Chloride, PtCl_2 , is obtained when platinic chloride is heated gently, until chlorine ceases to escape; it is a dark green powder, insoluble in

water. It forms with alkali chlorides, *chloroplatinites*, as 2KCl , PtCl_2 .

Platinic oxide, PtO_2 , and platinous oxide, PtO , and corresponding sulphides are known; also, a remarkable series of compounds, formed by action of ammonia upon platinum salts, called ammoniacal platinum compounds, as



IRIDIUM and OSMIUM are heavier than platinum; the sp. gr. of Ir being 22, and of Os, 22.5. Their atomic weights are near that of platinum, being 192.7 and 198.6 respectively. Iridium is not acted on by the air, nor is it soluble in aqua regia. It resembles polished steel, is brittle and very hard, and is often alloyed with platinum, in the form of wire and posts, for crown and bridge work.

The remaining congeners of platinum are Palladium, Rhodium, and Ruthenium; their sp. gr. are respectively 11.4, 12, and 11.4; their atomic weights are 106, 104, and 103. They are of little relative importance. Palladium has the property of absorbing hydrogen; the latter thus, is said to be *occluded*.

CHAPTER XVIII.

ELECTROLYSIS.

Any compound liquid, capable of conducting the electric current, is an *electrolyte*, and will suffer decomposition by an electric current, in direct proportion to its conducting power.

One of the sources of electric development is by chemical action, and an arrangement by which the force is utilized thus, is called a *galvanic*, or *voltaic battery*. Galvanic batteries are constructed of various substances, and in various forms: one principle, however, obtains in all, viz., unequal chemical action on conductors, in the exciting liquid. The simplest conception of a galvanic battery, may consider its construction as consisting of the metals, zinc and copper, immersed in dilute sulphuric acid; the zinc and copper are acted upon unequally by the acid, zinc more than copper; zinc is, therefore, electro-positive to copper, and the latter becomes electro-negative. Electricity developed at the zinc plate, is called *positive*; that at the copper plate, *negative*. Positive electricity passes *from* the zinc *through* the dilute sulphuric acid, and is

collected at the negative plate; so that if conducting wires be attached to the metals, the wire in connection with the copper will conduct *positive* electricity, and the one in connection with the zinc will be the negative conductor.

The extremities of these wires, or *rheophones* (*electrodes*), are denominated *poles*; or, *positive* pole and *negative* pole, respectively. When the conducting wires are in contact, or another conductor is interposed between them, the circuit is *closed*; otherwise the circuit is *broken*.

Other forms of battery, than the one described, are common. The *bichromate of potash* battery consists of the same materials, except it has *carbon* instead of *copper* for the negative element, and a solution of *potassium dichromate* mixed with the dilute sulphuric acid. The action of the acid on the zinc, as is well known, sets hydrogen free, which accumulates on, or *polarizes*, the negative plate, greatly interfering with the continuance of the current. The solution of the potash salt, is changed to chromic acid, which takes up the hydrogen, thus preventing the polarization referred to.

The liquid in such a battery consists of water, 1000 CC (fGm), = (2.11 pints), sulphuric acid, 350 CC = (11.85 f3), potassium dichromate, 230 Gm. (7 3). Dissolve the latter in boiling

water, 675 CC (1.36 pints), and when cool, add to the acid mixture.

The *poles* of the battery, when employed for the purpose of mere analysis, are usually tipped with platinum; and when these poles are immersed in a *compound liquid*, capable of conducting the current from pole to pole, decomposition of that liquid will ensue. The chemical affinity, *i. e.*, the attraction between the radicals of the molecules of which the liquid in question is constituted, will be overcome by the electric force, *at* the surface of the poles, the intermediate portion of the liquid being apparently unaffected. The following arrangement of the molecules of water, when under the influence of the electric current, will serve as a sufficient example, for the process of electrolysis in general:



The sign + in the above diagram, represents the positive pole of the battery, and the sign — the negative pole. It will be observed that free oxygen appears at the positive pole, this element is therefore electro-negative to hydrogen; and as hydrogen appears at the negative electrode, it is positive to oxygen. In this way, the electric status of each of the several *elements* is relatively determined.

Oxygen is the most electro-negative of the elements; it must therefore be placed first, in the fol-

lowing comparative series. The other elements are, severally, *electro-negative* to those which follow them, and *electro-positive* to those that precede them.

Electro-negative.

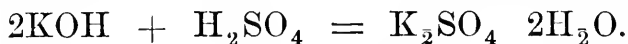
O	B	Sn	Ba
S	C	Pb	Li
N	Sb	Co	Na
F	Si	Ni	K
Cl	H	Fe	Rb
Br	Au	Zn	Cs
I	Pt	Mn	Electro-positive.
Se	Hg	Al	
P	Ag	Mg	
As	Cu	Ca	
Cr	Bi	Sr	

It will be further noticed that the *non-metallic* elements, as a class, are electro-negative, while the *metals*, comparatively, are decidedly electro-positive. The rarer elements are, for the most part, ignored in the above classification.

The *liquid* state is essential to an electrolyte; the thinnest film of ice is sufficient to arrest the electric decomposition of water. Mere solution, or fusion by heat, will accomplish the object. But all liquids are not *electrolytes*; water itself, when pure, is not a good conductor of the current, and therefore suffers only slight decomposition, even by a powerful battery; whereas, if it contains a

very small proportion of sulphuric acid, it is rendered a good conductor, and submits readily to the process of electrolysis. Alcohol, ether, and numerous other compounds of organic chemistry, and a few saline inorganic compounds, refuse to conduct, and thereby avoid decomposition.

When oxygen salts in solution suffer electrolysis, they are at first divided into free metal and a negative radical. Sulphuric acid (hydrogen sulphate, H_2SO_4), is split up into free hydrogen, which appears at the negative electrode, and *sulphione*, SO_4 , which appears at the positive electrode. In the same manner cupric sulphate, CuSO_4 , splits up into metallic copper and sulphione, SO_4 ; the SO_4 loses an atom of oxygen, which escapes, and the residue, SO_3 , unites with water to become H_2SO_4 . Sometimes the base of the salt is divided, so that free metal appears on the *cathode*, and metallic oxide on the *anode*. In case the metal is capable of decomposing water, as potassium, for instance, it will form a hydroxide, which will unite with the acid present, to reproduce the typical salt.



The amount of decomposition of each electrolyte is perfectly definite, and is expressed for each by the value of its chemical equivalent. The equivalent value of water is 9; of hydrochloric

acid, 36.5 ; of potassium iodide, 166. Now, the same current passing through these electrolytes, will cause simultaneous decomposition of 9 parts by weight of water, 36.5 of hydrochloric acid, and 166 of potassium iodide, and so on, for other electrolytes as well, according to the same rule.

The process of electrolysis is subservient to many useful applications in the arts, such as *electro-plating* with gold, silver, nickel, etc., and lately with iridium. In the making of *electrotype*, by which the copper from cupric sulphate is deposited in the impression of the type, set up in the usual way, forming a coherent matrix for a permanent duplicate cast. *Fac similes* of engraving plates, medals, casts, etc., are obtained in this manner, and the wonderful invention of *photo-gravure* depends on this process of electrolysis.

For plating surfaces with silver or gold, the *cyanide* of the metal, obtained by reaction between silver chloride, AgCl , or gold trichloride, AuCl_3 , and solution of potassium cyanide, KCN , is the usual electrolyte.

A recent application of this process consists in the deposition of silver, on plaster models of the maxilla, for base-plates for artificial teeth. The plaster is covered with graphite, which serves as a conductor, outlining the size of the plate needed.

This is attached to the negative pole of the battery, and metallic silver to the positive pole. The latter is dissolved, more or less, by the influence of the electric current, thus keeping up the strength of the liquid, while the liquid itself, AgCN , in solution, is decomposed, the silver going to the negative pole until the required thickness of the plate is obtained. Then, by an analogous process, the silver plate receives sufficient deposition of gold to render the finished base all that may be desired for the purpose.

In all cases the article to be plated must be in connection with the negative pole, inasmuch as the electro-positive radical (metal), of the electrolyte, is set free at the negative electrode. The positive radical always appears at the negative pole, and the *negative* radical at the *positive* pole.

Storage batteries are plates which become polarized by receiving, on the prepared surfaces, electro-deposition of certain substances. These substances undergo further chemical change by being placed in a liquid able to act chemically on them, by which a secondary current is produced. For example, if a lead salt be decomposed by electrolysis, metallic lead will be deposited on the cathode (negative pole), and lead dioxide, PbO_2 , on the anode (positive pole). When plates

thus prepared are placed in dilute sulphuric acid and properly connected by outside conductors, a current, reverse from the original, is developed by the resulting chemical change; the lead becomes oxidized and the lead dioxide is reduced. In the majority of cases hydrogen and oxygen are the polarizing agencies, and thereby prove once more that force, like the "coon, may be caught a coming or a going:"

The *Faradic current* is an *induced*, interrupted current, produced by wrapping around a hollow cylinder of wood, thick, insulated copper wire, the *primary* coil; the *secondary* coil, made of thinner wire, is wrapped around the insulated first coil. The hollow cylinder contains a bundle of soft iron wire, which acts as a *magnet*, when a current of electricity is passed through the inner coil. Near the end of the soft iron wires there plays a bar, also of soft iron, regulated by a spring, the latter being in electric connection with the primary coil. The current passing through the primary coil, *induces* a secondary current in the outer coil, and in the opposite direction; the soft iron bundle is *magnetized* by the current at the same time, and attracts the soft bar of iron, whose removal thus, *breaks* the current. In consequence of the *break*,

the bundle of iron is *demagnetized*, permitting the iron bar to assume its former position, which occasions a repetition of the phenomena, so long as the current is supplied. The induced current is necessarily a *make* and *break*, or, *to* and *fro* current, the stronger shock being received from the *break*.

CHAPTER XIX.

PERIODIC LAW.

THE PERIODIC LAW.—From the very earliest historic times, the theories advanced in regard to the ultimate nature of matter, possessed a peculiar charm; The discovery of oxygeu by Priestly, in 1775, lent a fresh impetus to these studies.

Guyton de Morveau, in 1782, suggested the first idea of systematic chemical nomenclature, followed by Lavoisior, who elaborated the idea so fully, that the present system of chemical nomenclature and notation may be considered, with a few improvements, to be Lavoisian. The atomic theory of Dalton, later, accounted satisfactorily for the *mathematics* of chemical reactions; and the relations between the constants of the elements and their specific heats, and the electric behavior of the elements themselves, seem to confirm the truth of Dalton's theory. Prout's hypothesis, in 1816, that the atomic weights of the several elements might be considered as exact multiples of the atomic weight of hydrogen (a theory, by the way, which is only slightly at variance with the present

accepted atomic weights, and which may be sustained by further corrections), was followed by the suggestion that possibly hydrogen was the "primordial matter that forms the other elements, by successive condensations of itself."

In 1864 and 1870, Newlands and Mendelief, respectively, independently of each other, erected tables of the then known elements, beginning with those of the lowest atomic weights, and advancing regularly to the highest. They observed a natural grouping of the elements that appeared to bear some relation to their several atomic weights, and to their quantivalence when determined by their oxygen compounds; hydrogen alone, seeming to be especially isolated from the rest. Therefore, leaving hydrogen to itself, if we begin with the element of next lowest atomic weight, viz., monad-lithium, we find the progression to be as follows:

1. H, — — — — — —
2. Li7, Be9, B11, C12, N14, O16, F19 —
3. Na23, Mg24, Al27, Si28, P31, S32, Cl35.5

If we study the position of the above elements, we perceive that those to the left are *metallic*, and those to the right are *non-metallic*, while the intermediate elements, like silicon, possess chemical properties intermediate between the two extremes. We notice that the line, commencing with Li, ends ab-

ruptly, with the *acidulous* fluorine, inasmuch as the element of next atomic weight, Na, is decidedly *basic*, and hence introduces another *period*. We notice, further, that the corresponding members of both *periods* have corresponding valencies, so that if placed in *vertical* columns, all those in the same column possess the same valency. The elements in each *group*, in the following table, arrange themselves naturally in double columns, those on the same side resembling each other in chemical properties. Each *series* is a *small period*; series 1 and 2 the *first large period*; series 3 and 4 the *second*, etc. R represents one atom of any element, as RO means one atom, united to one of oxygen, or R_2O , two atoms, etc.

The blank spaces in the foregoing table indicate the probably proper places of elements as yet unknown. Mendelief predicted the existence of two elements — *eka-aluminum* and *eka-boron* — which should fill the places now occupied by gallium and scandium respectively, and described the general physical and chemical properties of these elements in advance of their discovery.

In consequence of the periodic law, the suggestion is now accepted as truth, that “the properties of an element are a periodic function of its atomic weight.” Those elements that unquestionably belong to the same group, often present remarkable coincidences with reference to their atomic weights. Thus, the atomic weight of sulphur is twice that of oxygen, and if the atomic weights of sulphur, 32, and of tellurium, 125, be added together and the product divided by 2, the result will be in the immediate neighborhood of 78, the atomic weight of selenium. Again, the atomic weight of phosphorus, 31, and of antimony, 120, added together, give us the number 151, which is almost exactly twice 75, the atomic weight of arsenic. The sum of the atomic weights of chlorine, 35, and of iodine, 127, is 162, which, divided by 2, brings us sufficiently near the atomic weight of bromine, 80, as to appear something more than a mere coincidence.

CHAPTER XX.

SPECTRUM ANALYSIS.

In concluding the history of the individual elements, as well as many of their binary compounds, it will not be inappropriate to allude briefly to the subject of "spectrum analysis."

When sunlight is passed through a prism, it is split up into what are arbitrarily called the "seven primary colors of the solar spectrum." The colors, however, of solar light, strictly speaking, are not confined to merely seven in number, but are manifested in infinite variety, each corresponding to a special "wave length." Sunlight furnishes a continuous band of light, broken by a great number of fine dark lines; but if the light from incandescent individual terrestrial elements be dispersed by passing through a prism, it will be found that only a few colors are shown consisting of *bright* lines, which are characteristic only of the elements present in a state of luminosity, by which condition their spectra are exhibited.

The instrument for examining the light given off by special substances, is called the "spectro-

scope," and the process itself is called "spectrum analysis."

When compounds of sodium are heated in a common flame sufficiently, the yellow light of sodium will confer on the flame a yellow color. In the same way potassium compounds will cause the flame to assume a decided violet tint. If there be present in the flame both sodium and potassium compounds, the intense yellow sodium light will so overcome the purple potassium color that the presence of the latter element, although, perhaps, in excess, will not be detected. If compounds of either one of these elements be examined by the spectroscope, the light of sodium will be indicated by *two* bright, slightly different shades of yellow, lines, so close together that ordinary instruments show them as one bright yellow line. The light of potassium will exhibit several bright lines, widely separated, varying in color from strong violet to red. Now, if compounds of both sodium and potassium be examined simultaneously by the spectroscope, the peculiar yellow lines of sodium and the purple and red and intermediate lines of potassium will all appear distinctly, so that the presence of both elements in the substance undergoing examination in this way can be ascertained with certainty.

The metals thallium, cæsium, rubidium, indium, gallium, and others were discovered by this process.

Barium gives lines of light of several different colors, ranging from green to red; strontium, brilliant shades of red and two of blue; thallium, only one—a splendid blue line; and calcium, quite a number of lines, the yellow predominating. The other metals also: gold, platinum, silver, iron, etc., may each be recognized by the peculiar bright lines belonging to their spectra. Nitrogen exhibits a spectrum, mostly purple; and hydrogen one bright red, one green, and one blue line.

Liquids and solids, when heated to incandescence, exhibit continuous spectra. It is only luminous *vapors* that give discontinuous, bright line spectrums. To obtain this luminous vapor of those elements which require a higher temperature for the purpose, than can be conferred by a Bunsen flame, the electric spark is employed, which in passing between two points of the metal in question, volatilizes a portion, or in passing through gases, as hydrogen, etc., heats them so intensely as to enable them to give off the peculiar light characteristic of each.

The spectrum of the sun, when examined by means of the spectroscope, is found not to consist

of an absolute continuous band of light, ranging from red to violet, but is seen to be interspersed by hundreds of *dark* lines, and these lines are observed to correspond in exact position to the *bright* lines in the spectra of terrestrial elements.

This coincidence in the position of the dark solar lines with the well-known bright terrestrial lines, led to the assumption that the dark and bright lines were produced by the same incandescent elements. Later experiments proved such assumption to be a fact. The brilliant *lime* light thrown on the field of the spectroscope shows a continuous band of light similar to that of the sun. If, however, the sodium flame be interposed between the lime light and the spectroscope, the continuous spectrum will show a double dark line corresponding to the bright lines of sodium alone. The conclusion is, therefore, reached "that the vapor of an element has the power of absorbing light-rays of the same wave length as those it emits." In other words, the luminous sodium vapor stops the light of the same wave length or color, proceeding from the brilliant lime light behind it. It is *opaque* to the colors of its own kind, and allows the rest to proceed.

The physical condition of the sun is at once indicated by these experiments of Kirchoff. It consists of a central incandescent liquid or solid body which *reverses* the light of the luminous vapors of the various elements in its own photosphere, changing the otherwise *bright* lines into *dark* lines, and these dark solar lines, corresponding in position to familiar terrestrial bright lines, prove the existence of the vapor of certain elements in the atmosphere of the sun, with as great a degree of certainty as any other question in physical science.

Oxygen, hydrogen, iron, nickel, cobalt, manganese, calcium, strontium, barium, chromium, magnesium, sodium, copper, titanium, aluminum, lead, cerium, cadmium, and uranium, have been identified as solar elements. The planets give the same lines as those of the sun, as they shine by reflecting his light.

Similar methods of observation prove the fixed stars to be self-luminous suns. Many well known elements have been recognized in the star Aldebaran, and some also not as yet detected in the sun, as bismuth, antimony, mercury, and tellurium.

The true *nebulæ* are ascertained to consist of masses of glowing gas, inasmuch as they give

bright lines, indicating only, with certainty, the presence of hydrogen, a fact which seems to prove the *nebular hypothesis*, and also the evolution of the various kinds of matter from one primordial element.

PART THIRD.

ORGANIC CHEMISTRY.

CHAPTER I.

INTRODUCTORY REMARKS.

There is but one science of chemistry. Its division into *inorganic* and *organic*, is simply one of convenience.

It was formerly supposed that the production of organic chemical compounds was restricted to the influence of vital force in the bodies of plants and animals. There is now, however, no boundary line between the two divisions, inasmuch as many organic compounds can be produced synthetically from inorganic materials, and many others, such as indigo, carbolic acid, etc., may be obtained by artificial means. But nevertheless, the practical source of organic compounds is from substances of animal or vegetable origin, so that those who erected organic chemistry into a separate science really builded better than they knew, by presenting a division most convenient for the separate

consideration of the chemical nature of carbon and its relations to the other elements.

Organized structures, that is to say, the various *tissues* of animal and vegetable bodies, can not be produced artificially. They are made up of chemical combinations which obey, in unison with natural affinities, the governing power of *vitality*. When vitality ceases, these tissues undergo resolution toward the formation of simple chemical compounds, unless their identity is preserved by immediate antiseptic treatment. When subjected to a high temperature, with access of air (oxygen), they are resolved at once, principally into H_2O and CO_2 ; and if subjected to *destructive distillation*, volatile and liquid substances are given off, leaving a residue consisting of the charcoal variety of carbon; and finally, if left exclusively to nature's processes, *decay* supervenes by the agency of micro-organisms; rapidly or slowly, according to the nature of the substance, and its exposure to moisture and certain temperatures.

Spontaneous disorganization of substances, rich in nitrogen, is called *putrefaction*. They give off compounds of an unpleasant odor, consisting largely of ammonia and its derivatives; whereas those bodies of a non-nitrogenous composition, losing their identity thus, are said to undergo *fer-*

mentation. In the latter case, the compounds resulting are mainly devoid of unpleasant odors.

There is no essential difference in the *nature* of the disorganization in those processes termed as putrefaction, fermentation, and *eremacausis*, except in so far as the substances involved differ in chemical composition; but the part played by micro-organisms in the phenomena of changing complex bodies into simpler forms, is as yet undetermined, and would be out of place in a work of this kind, even if we had fixed theories on the subject. It will, therefore, be sufficient to remark in this connection that micro-organisms are of various kinds, and possess various functions. Some kinds of micro-organisms, the *saprogenic*, will affect changes only in nitrogenous material, and even here, there are many species of the useful pests, which divide the process of putrefaction into several well marked stages. This fact also obtains in fermentation. Juices of various fruits, such as apples, etc., freely exposed to the air and proper temperatures, undergo changes finally resulting in alcohol (cider), and this, if left to itself, by the agency of a special micro-organic germ or ferment (*the microdermi aceti*), will change into vinegar, otherwise known as acetic acid. In the same way, special germs, acting on different substances, induce individual distinc-

tions in fermentation, such as lactic, butyric, etc. In a given culture (decomposable substance), artificially prepared, as solutions of the carbo-hydrates, lactic acid will result, by the influence of quite a number of different bacteria, some of them known as *pathogenic* (disease-producing), and others as non-pathogenic.

The tendency of fermentation is to produce *acids*; of putrefaction, to produce *alkalies*. In the latter case, as already alluded to, ammonia and its derivatives, the amines and amides are characteristic, together with exceedingly poisonous and non-poisonous diffusive *ptoma-ines*, or animal alkaloids, resembling in their chemical nature, well-known vegetable alkaloids, such as strychnine, atropine, morphine, etc.

If the substance undergoing transformation by bacterial influence, be composed of both fermentive and putrefactive materials, then both acid and alkaline products will occur. The fluid contents of the average human mouth, consisting of normal saliva, mucus, and remains of various kinds of food, afford an excellent example of a heterogeneous culture, and as more than twenty different kinds of bacteria have been detected in the oral cavity, it is easy to realize that in such a state of affairs, *chemical riots* will be the rule; acid fermentation, tend-

ing to destroy the structural integrity of the teeth, and alkali fermentation (putrefaction), tending to induce an inflammatory condition of the softer tissues of the mouth, oftentimes accompanied by swellings and general septicæmia, the latter symptom owing probably to the resorption of the poisonous ptomaines.

As counteracting influences opposed to the above conditions, we have the means of killing the microbes direct, by the employment of *germecides*, and by *disinfection*, which destroys the infectious matter, and at the same time changes the physical, or chemical, nature of the culture, so that it can not serve any longer as suitable soil for microbial propagation. *Antiseptics* applied to the part, *and continued*, after disinfection, will prevent a recurrence of the fermentive process.

Germicides *per se*, are of little value as medicines, so long as the culture remains intact, for, as we may readily believe, the presence of living germs of the common forms of both phases of fermentation is practically universal. *Disinfection*, therefore, is the Samson upon which the dental surgeon should rely, followed by the exhibition of antiseptics, to prevent a return of the disease.

The terms disinfectants and antiseptics, are often improperly used indiscriminately; and although it

is impossible to draw a sharp line of demarcation between these two classes of remedies, inasmuch as some members of each (like silver nitrate, salicylic acid, etc.), act more or less, in both capacities, we will presume to draw a few distinctions between them, which, on account of necessary brevity, will no doubt appear rather too dogmatic.

It is a question yet in doubt as to whether full grown micro-organisms, *bacteria*, exist in all infectious matter; their absence therein does not, therefore, disprove the bacterial genesis of disease, or of their necessary presence in inducing chemical changes in the organized tissues that have lost wholly, or in part, the governing power of vitality. Their *spores* can yet live in the excrementitious matter, and when planted in congenial soil, will *sprout* and grow into the characteristic *bacilli* of their kind. Poisonous ptomaines alone, when forced into healthy living tissues play an important part, not yet understood, in the production of acute diseases. It follows accordingly, that any means by which remaining bacteria, spores, and ptomaines can be completely destroyed, must be credited as belonging to the class of thorough disinfectants.

Disinfection can be accomplished in various ways.

First, by mechanical means; removing the infec-

tious matter beyond the sphere of possible reproduction ("to the bottom of the sea").

Second, by extremes in temperature, especially a high temperature, which kills bacteria, and spores, and changes the chemical nature of the culture in which they thrive, and also the poisonous products of decomposition.

Third, by chemical means; chemical action, as we know, causes complete loss of identity in the acting bodies, and where chemical changes take place in infectious matter, it necessarily loses its power of infection. Oxygen is involved in this form of disinfection more than all other material agencies combined. In the process of *fumigating*, by burning sulphur, the freshly formed sulphurous oxide (SO_2), deoxidizes the injurious organisms and compounds, by taking away some of their structural oxygen, which change, of course, destroys their identity. On the other hand, such incontestible disinfectants as peroxide of hydrogen, potassium permanganate, chlorinated lime, chlorinated soda, etc., furnish active oxygen, which as stated under their several heads, burns up the infectious material, in the same way that nature's great disinfectant, *ozone*, accomplishes its peculiar function.

The removal of all infected matter in caries of the teeth, by instruments, is *disinfection*. Anti-

septic measures are then adopted, by proper methods of filling the cavity, to *prevent* a return of the destructive phenomena in that part of the tooth. Or complete removal of the contents in root canals by instrumental manipulation, is thorough disinfection of the part, a labor requiring infinite care, and which is generally supplemented by aid of chemicals and a high temperature, followed by the insertion of antiseptics, as the phenols, iodoform, essentials oils, etc., in connection with the sealing qualities of the filling.

A healthy part does not need disinfection, but it does require antiseptic treatment, to prevent the development of disease. The judicious use of the tooth-brush, in a healthy mouth, is antiseptic treatment by *cleanliness*, tending to keep the parts therein in a healthy condition; much alike in principle and object to the treatment of fresh meats by the use of the *antiseptic*, common salt. We might multiply examples indefinitely to prove our thesis, but the above brief remarks, we hope, will enable the student to appreciate the distinction that really exists between the two classes of remedies known as disinfectants, and as antiseptics.

CHAPTER II.

CARBON COMPOUNDS.

The four points of attraction possessed by the atom of carbon, furnish the basis by which organic compounds are classified. These compounds are made up, mainly, of carbon, hydrogen, and oxygen, but many of them contain nitrogen, phosphorus, and sulphur; also the haloid elements and various metals.

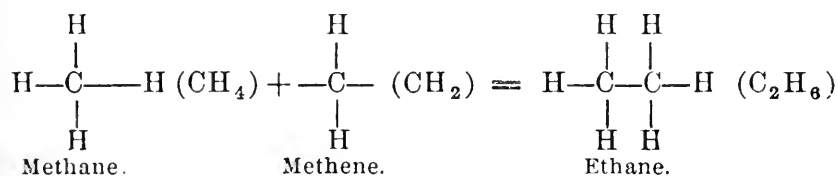
Methane, CH_4 , serves as the best prototype of organic compounds. As will be observed by its

formula, one atom of tetrad carbon $\begin{array}{c} | \\ \text{---C---} \\ | \end{array}$ has its

valency of four, completely satisfied by union with the four atoms of monad hydrogen; so that the *saturated* compound is not able to take up any more monad atoms, except by displacement of an equivalent number of the hydrogen atoms. In a previous chapter, however, we alluded to the fact that any dyad radical, elementary or compound, can enter into direct combination with a saturated compound, because the two units of combining power, belonging to the dyad, so act as to neutral-

ize one unit of the compound it enters, and introduce another, leaving the equivalency of the compound the same as before.

Consequently, methane may take up the dyad radical CH_2'' to form C_2H_6 , as may be easily understood by the *graphic* formulas.



On the other hand, methane, CH_4 , under certain circumstances, may lose two of its hydrogen atoms, resulting in the development of the above dyad radical methene; and ethane, C_2H_6 , may lose two of its hydrogen atoms, and a new series of hydrocarbon compounds be thus obtained.

The following table of some of the hydrocarbons, arranged and named by Hoffman, will enable the student to appreciate the above statements:

CH_4 Methane.	CH_2 Methene.				
C_2H_6 Ethane.	C_2H_4 Ethene.	C_2H_2 Ethine.			
C_3H_8 Propane.	C_3H_6 Propene.	C_3H_4 Propine.	C_3H_2 Propone.		
C_4H_{10} Quartane.	C_4H_8 Quartene.	C_4H_6 Quartine.	C_4H_4 Quartone.	C_4H_2 Quartune.	
C_5H_{12} Quintane.	C_5H_{10} Quintene.	C_5H_8 Quintine.	C_5H_6 Quintone.	C_5H_4 Quintune.	C_5H_2
C_6H_{14} Sextane.	C_6H_{12} Sextene.	C_6H_{10} Sextine.	C_6H_8 Sextone.	C_6H_6 Sextune.	C_6H_4 , etc.

Greek prefixes are generally preferred; thus *pentane* instead of *quintane*; *hexane* instead of *sex-tane*; *heptane* instead of *septane*, etc.

Now, by reference to the table, it will be noticed that the compounds in each vertical column differ successively from each other, by CH_2 ; and those in each horizontal line, differ from each other successively by H_2 . Those in each vertical column, form each a *homologous series*, and those on horizontal lines, an *isologous series*. The latter are also called the *monocarbon*, *dicarbon*, *tricarbon*, groups, etc.

The lowest member of each homologous series, leaving out a few which are not known to exist, is

presented below as far as the eighteenth, together with the *general* formula for each :

Series.	Lowest Member.	General Formula.
1.....	CH_4	$\text{C}_n\text{H}_{2n+2}$
2.....	C_2H_4	C_nH_{2n}
3.....	C_2H_2	$\text{C}_n\text{H}_{2n-2}$
4.....	C_5H_6	$\text{C}_n\text{H}_{2n-4}$
5.....	C_6H_6	$\text{C}_n\text{H}_{2n-6}$
6.....	C_8H_8	$\text{C}_n\text{H}_{2n-8}$
7.....	C_8H_6	$\text{C}_n\text{H}_{2n-10}$
8.....	C_{10}H_8	$\text{C}_n\text{H}_{2n-12}$
9.....	$\text{C}_{12}\text{H}_{10}$	$\text{C}_n\text{H}_{2n-14}$
10.....	$\text{C}_{14}\text{H}_{12}$	$\text{C}_n\text{H}_{2n-16}$
11.....	$\text{C}_{14}\text{H}_{10}$	$\text{C}_n\text{H}_{2n-18}$
12.....	$\text{C}_{17}\text{H}_{14}$	$\text{C}_n\text{H}_{2n-20}$
13.....	$\text{C}_{16}\text{H}_{10}$	$\text{C}_n\text{H}_{2n-22}$
14.....	$\text{C}_{18}\text{H}_{12}$	$\text{C}_n\text{H}_{2n-24}$
15.....	$\text{C}_{20}\text{H}_{14}$	$\text{C}_n\text{H}_{2n-26}$
16.....	—————	$\text{C}_n\text{H}_{2n-28}$
17.....	$\text{C}_{22}\text{H}_{14}$	$\text{C}_n\text{H}_{2n-30}$
18.....	$\text{C}_{26}\text{H}_{20}$	$\text{C}_n\text{H}_{2n-32}$

C_n means any number of carbon atoms, and H_{2n+2} , twice as many hydrogen atoms and 2 over; C_nH_{2n} , twice as many hydrogen atoms as as carbon atoms; $\text{C}_n\text{H}_{2n-2}$, twice as many hydrogen atoms as carbon atoms, minus 2, etc.

The hydro-carbons in the first vertical column

on page 254 (series C_nH_{2n+2}), are all saturated compounds; those in the second column (series C_nH_{2n}) are *dyad* radicals, capable of uniting with 2 atoms of chlorine without displacing hydrogen, as in ethene chloride, $C_2H_4Cl_2$; those in the third column, are triads, etc.

The first members, as methane, CH_4 ; ethane, C_2H_6 ; propane, C_3H_8 ; ethene, C_2H_4 ; ethine, C_2H_2 , etc., are gaseous at ordinary temperatures, and increase in density in regular ratio, with each additional CH_2 .

The higher members, of which $C_{35}H_{72}$ is the extreme, are solid; while the intermediate members, such as tetrane (quartane and butane), C_4H_{10} ; decane, $C_{10}H_{22}$, etc., are liquid. The boiling points of the liquid hydrocarbons increase regularly, but in diminishing ratio with each increase of CH_2 . Thus:

Tetrane, C_4H_{10} ,	boils at	0° (32F)	Increase.
Pentane, C_5H_{12} ,	" "	38° (100)	38 C.
Hexane, C_6H_{14} ,	" "	69° (156)	31
Heptane, C_7H_{16} ,	" "	98° (208)	29
Octane, C_8H_{18} ,	" "	124° (255)	26

CHAPTER III.

CARBON COMPOUNDS.

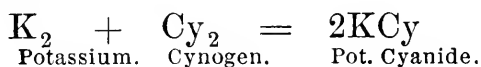
The hydro-carbons, containing an *even* number of hydrogen atoms, may exist free. Many of them are known.

Hydro-carbon radicals, containing an *uneven* number of hydrogen atoms, do not exist free, but nevertheless maintain their integrity through operations of decomposition and recomposition, just like the elements themselves, ranking as units, like the atoms of hydrogen, oxygen, gold, etc. They are derived from the hydro-carbons of even equivalency, in the same way that hydroxyl (HO), is derived from H_2O . A few of the most common occurrence are subjoined:

CH_4 Methane.	CH_3 <i>Methyl.</i>	CH_2'' Methene,	CH''' <i>Methenyl.</i>
C_2H_6 Ethane.	C_2H_5 <i>Ethyl.</i>	C_2H_4'' Ethene.	C_2H_3''' <i>Ethenyl.</i>
C_3H_8 Propane.	C_3H_7 <i>Propyl.</i>	C_3H_6'' Propene,	C_3H_5''' <i>Propenyl.</i>
C_4H_{10} Butane.	C_4H_9 <i>Butyl, etc.</i>		

The final syllable *yl* indicates a compound radi-

cal of *uneven* valency; so also certain radicals of both *uneven* and *even* valency, not derived from saturated hydrocarbons, as nitryl, NO_2 , carbonyl, CO , etc. The derivation of certain other radicals suggest their names; thus from ammonia, NH_3 , by abstraction of one atom of hydrogen, is derived *amidogen*, NH_2 ; and by taking away two atoms of hydrogen from NH_3 , is derived the dyad radical, *imidogen*, NH'' . *Cyanogen* (meaning *blue*), CN (quasi symbol Cy), when free, is formulated as CN-CN , analogous to the molecule of chlorine, Cl-Cl , and when acted upon by a metal, as K_2 , results according to the equation,



Just like a molecule of chlorine on a molecule of potassium, $\text{K}_2 + \text{Cl}_2 = 2\text{KCl}$. The *radical cyanogen*, CN , (Cy) is one-half the molecule of free cyanogen, just as the atom of chlorine, Cl , is the radical of the free molecule of chlorine, Cl-Cl .

These latter compound radicals, carbonyl, nitryl, amidogen, imidogen, and cyanogen, are not strictly classified as organic, but are interesting in this connection, inasmuch as they enter largely into the formation of many accepted organic compounds.

The hydrocarbon radicals, however, such as

methyl, methenyl, ethyl, propyl, etc., are the ones that should engage our especial attention in studying organic chemistry. They behave, as before remarked, similarly to the atoms of the elements, and like the latter, are relatively electro-positive or electro-negative. With O, Cl, etc., they are electro-positive, as in ethyl oxide, $(\text{CH}_5)_2\text{O}$, and ethyl chloride, CH_5Cl ; and electro-negative, in metallic salts, as in lead ethide, $\text{Pb}(\text{CH}_5)_2$.

From them, all well defined organic compounds may be presumed to be formed, most of which may be assumed to be derived from the following members:

1. ALCOHOLS.—Formed by the union of hydro-radicals with hydroxyl.

CH_3, OH	$\text{C}_2\text{H}_5, \text{OH}$	$\text{C}_2\text{H}_4(\text{OH})_2$	$\text{C}_3\text{H}_5(\text{OH})_3$
Methyl Alcohol.	Ethyl Alcohol.	Ethene Alcohol.	Propenyl Alcohol.

Alcohols are really *hydroxides*, analogous to the hydroxides of metals. Thus sodium hydroxide, NaOH , calcium hydroxide, $\text{Ca}(\text{OH})_2$: The first is similar in composition to methyl and ethel alcohols, and the latter to ethene alcohol.

2. OXYGEN ETHERS.—Are formed after the water type, H—O—H , and consist of hydrocarbon radicals and oxygen. Common ether is ethyl oxide, $\text{C}_2\text{H}_5\text{—O—C}_2\text{H}_5$. A *mixed* ether contains more than one hydrocarbon radical; methyl-ethyl ether, $\text{CH}_3\text{—O—C}_2\text{H}_5$, is a mixed ether.

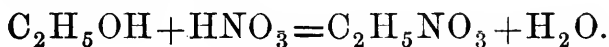
3. HALOID ETHERS, are compounds containing hydrocarbon radicals, and a haloid element; chloroform, CHCl_3 is a haloid ether, made up of the trivalent hydrocarbon radical methenyl, and three atoms of univalent chlorine.

Iodoform CHI_3 , and "Dutch Liquid" $\text{C}_2\text{H}_4\text{Cl}_2$, are also examples of haloid ethers.

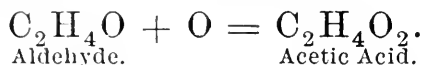
4. ORGANIC ACIDS, may be defined as oxygenated hydrocarbon radicals and hydroxyl, as acetic acid $\text{C}_2\text{H}_3\text{O}$, OH , formic acid CHO , OH , lactic acid, $\text{C}_3\text{H}_5\text{O}_2$, OH . The molecule of an organic acid, therefore contains at least two atoms of oxygen; they may also be regarded as being produced by union of a hydrocarbon residue and the univalent radical *carboxyl* COOH , graphically $\text{O}=\overset{\textstyle |}{\text{C}}-\text{O}-\text{H}$, thus acetic acid CH_3COOH ; formic acid, H , COOH ; lactic acid $\text{C}_2\text{H}_5\text{O}$, COOH . Where but one group of carboxyl is shown, as in the above, such acid is *monobasic*, giving up only the hydrogen of carboxyl to a metal; and when two such groups are shown,

as in succinic acid, $\begin{array}{c} \text{CH}_2-\text{COOH}, \\ | \\ \text{CH}_2-\text{COOH}, \end{array}$ it is *dibasic*.

5. ESTERS, are ethereal salts, formed by hydrocarbon radicals, and organic or inorganic *acid* radicals, for example ethyl acetate, C_2H_5 , $\text{C}_2\text{H}_3\text{O}_2$. Ethyl alcohol and nitric acid, yield the *ester*, ethyl nitrate, and water.



6. ALDEHYDES, meaning less hydrogen than is contained in the corresponding alcohols, are compounds, intermediate between alcohols and acids. That is, they contain less hydrogen than the alcohol, and less oxygen than the corresponding acid, and are derived by the removal of hydrogen from the alcohol, by oxygen, all of which may be understood by the *empirical* formulas :

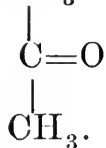


An aldehyde can be converted into an alcohol, but an acid can not.

7. KETONES are derived from aldehydes, by replacing one atom of hydrogen by an alcohol radical.

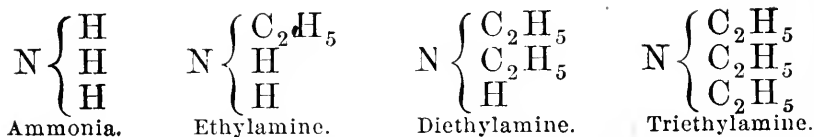


or they may be considered graphically as two univalent radicals, held by bivalent carbonyl CO. The ketones are quite numerous, of which *acetone* is the best prototype. Acetone itself, may be regarded as dimethyl ketone CH_3



There are also diethyl, and ethyl-methyl, etc., ketones.

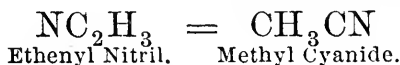
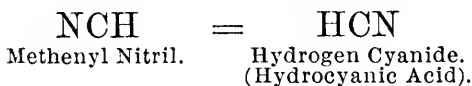
8. AMINES, are derivatives of ammonia by substitution of hydrogen, by hydrocarbon radicals.



The amines are numerous, and are mostly basic in character. Where all the hydrogen is removed, the trivalent radical N is evidently capable of taking up three univalent radicals as above, or one trivalent radical, as below :

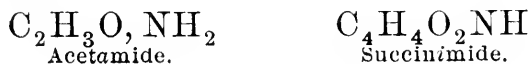


These trivalent nitrils are not basic; they are all neutral, except the first, which is acid, capable like HCl, of exchanging its hydrogen for a metal, and may therefore be regarded as composed of hydrogen and the univalent radical cyanogen,



Analogous to the *amines*, are the *arsines*, *stibines*, and *phosphines*.

9. AMIDES are analogous to the amines in composition, except they contain *acid* radicals, instead of hydrocarbon radicals. Those which are made up of a bivalent acid radical, and imidogen, are called *imides*.

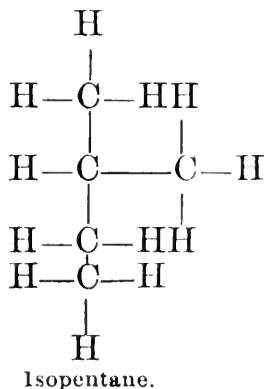
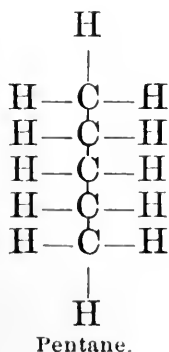


CHAPTER IV.

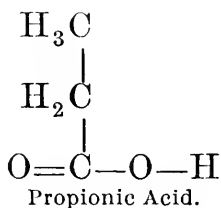
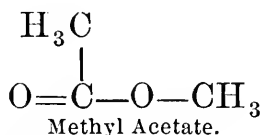
CARBON COMPOUNDS.

When two or more compounds can be represented by the same empirical formula, they are said to be *isomeric*. The difference in the chemical and physical nature of isomeric bodies, is due to the difference in the relative position, or arrangement, of the atoms in the molecule, and it is upon this fact that the somewhat startling innovation of *stereo-chemistry* is founded.

True isomeric bodies are those which have the same kind and number of atoms, not grouped into special compound radicals. These isomers react similarly, by the influence of the same reagents. There are many examples of this class, two of which will suffice :



Metameric isomers, are those bodies which have the same composition, but differ greatly in their transformations under similar circumstances; as an example, the formula $C_3H_6O_2$ represents methyl acetate, ethyl formate, and propionic acid, two of which we subjoin graphically.



Polymeric compounds are those which have the same percentage composition but differ in molecular weight. Examples of this class are found in the series, homologous with CH_2 :

Ethene (ethylene) C_2H_4 .

Propene (propylene) C_3H_6 .

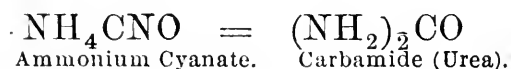
Tetrene (butylene) C_4H_8 .

Pentene (amylene) C_5H_{10} .

Several essential oils are isomeric with oil of turpentine, $C_{10}H_{16}$; and others are polymeric with the latter, having the formulas, $C_{20}H_{32}$, $C_{30}H_{48}$, etc. All polymeric compounds, exhibit regular gradation in density, and boiling points, from the lowest to the highest.

OPTICAL ISOMERISM, possessed by similar compounds, is due, according to stereo-chemistry, to asymmetric carbon atoms in each molecule.

The above examples of isomerism show the importance of *rational* formulas. The empirical formula of methyl alcohol, for instance, is CH_4O . The rational formula is CH_3OH . The formula $\text{C}_2\text{H}_4\text{N}_2\text{O}$, expresses the number and kind of atoms in both *ammonium cyanate* and *carbamide*, and might also be supposed to suggest the direct union of methane and nitrous oxide; but if each be formulated rationally, we can then have easy conception of differences in their chemical and physical properties.

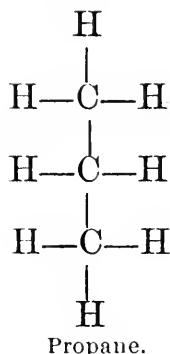
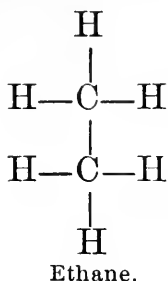
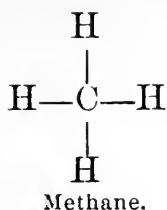


Ammonium cyanate can be prepared from inorganic sources. Its molecular transformation into urea by Wohler marked the first artificial production of an organic compound.

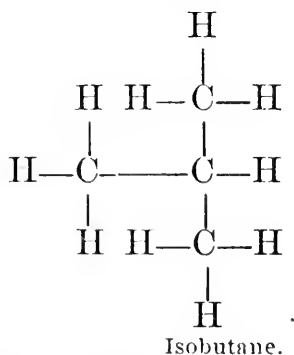
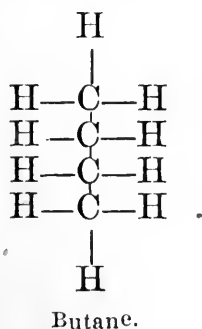
CHAPTER V.

PARAFINS, SERIES C_nH_{2n+2} .

The formulas of the first members of the methane series of hydrocarbons, suggest a symmetrical arrangement of the atoms of hydrogen, in connection with the atom of carbon. The four points of attraction belonging to the latter, are properly represented by the four solid angles of a tetrahedron, to each of which is attached an atom of hydrogen in methane. In the next member, ethane, containing two atoms of carbon, one point of attraction belonging to each, is united to the other, leaving 3 points free to unite with hydrogen, and so on with the next member, propane, where the middle carbon atom can satisfy only 2 of hydrogen. Such stereo arrangement can not be represented on a plane surface, except feebly in perspective, but the following diagrams will adequately express the mathematical values of each compound:



Modifications of these molecules are probably impossible, and therefore there are no *isomers* of methane, ethane or propane, but with the next member, butane, C_4H_{10} , it is possible to write the graphic formula in at least two ways; and it is a fact that two kinds of butane are recognized:

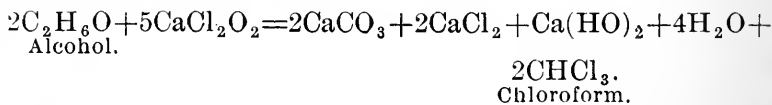


As the individual hydrocarbons, of this or other series, increase in the number of carbon atoms, it is evident that many modifications are possible, and a corresponding number of isomers may be produced. A mathematical limit, however, in each case, is also evident.

The methane series of hydrocarbons are found in petroleum. The first four members, are gases, the fifth a light liquid, and so on, increasing in specific gravity by each increase in CH_2 ; the latter members, being solid. Paraffin itself is a mixture of the higher members.

Methane, CH_4 , as well as each of the other saturated hydrocarbons is formulated rationally as a *hydride*, to indicate the presence of a compound radical which retains its identity in many reactions. For example, methyl hydride, CH_3 , H (methane), when acted on by chlorine forms methyl chloride CH_3 , Cl. Ethyl hydride C_2H_5 , H (ethane) similarly also forms, by losing an atom of hydrogen, ethyl chloride $\text{C}_2\text{H}_5\text{Cl}$, etc.

By acting on methyl chloride, with excess of chlorine, the *isologous* radical methenyl, CH , is produced; this takes up, 3 atoms of chlorine, and methenyl chloride, chloroform, CHCl_3 , results. Chloroform however, is commercially prepared, by distilling together, either methyl, or ethyl alcohol, and bleaching powder.



Chloroform is a haloid ether, of an agreeable odor. It is a colorless liquid, of specific gravity 1.52, and boils at 62° (143°F.). Its molecular

weight as seen by formula, is, in round numbers, 120; its vapor density compared with hydrogen, is one-half its molecular weight, or 60, and as air is nearly 15 times as heavy as hydrogen, the vapor of chloroform is therefore about 4 times as heavy as air.

The purest chloroform is now made from chloral hydrate. It possesses strong solvent powers on the different oils, camphor, caoutchouc, resins, the amines, and bromine and iodine. It is not inflammable; is freely soluble in ether, and alcohol, and sparingly so in water.

MATERIA MEDICA.—Chloroform has been a favorite anæsthetic from the period of its introduction in 1847, but on account of the many fatal cases which have occurred under its influence, it is being discarded more and more, in favor of ether. Its employment alone, or in combination with other anæsthetics, in the simple though painful operation of extracting teeth, is not regarded as legitimate practice by the highest authorities in our profession. It kills by direct heart paralysis, probably due to the physical change which chloroform produces in the blood itself. The strong tendency to immediate coagulation of fresh blood, by outside experiments with chloroform, is at least suggestive.

Locally applied, chloroform is an irritant, and reduces painful impressions in the part; it is also a good hæmostatic. Taken internally it is employed as an anti-spasmodic and anodyne.

Dose, 0.06–0.30 f Gm. (m i–v).

For inhalation 4.—8 f Gm. (fzi–ij).

IODOFORM, *methenyl iodide*, CHI_3 , is a haloid ether, analogous to chloroform, and, like the latter, is a derivative of methane. It is prepared by heating to a temperature of 40° (104°F), an alcoholic solution of potassium iodide with bleaching powder. It occurs in small yellow crystals, somewhat volatile, giving off an unpleasant saffron-like odor; is insoluble in water, but is freely soluble in oils, chloroform, ether and alcohol.

MATERIA MEDICA.—Iodoform is a typical antiseptic; applied to a disinfected part, it effectively prevents the development of both alkali and acid ferments. As a dressing to ulcerous sores, open and sloughing wounds, it is anæsthetic, and stimulates healthy granulations by preventing profuse discharge and consequent irritating sequelæ.

As an antiseptic dressing in root canals of teeth, it is favored by many of our most eminent practitioners, notwithstanding its rather enervating odor. This single objection to iodoform is easily overcome by the addition of either one of several

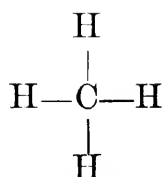
essential oils, which act both as adjuvans and coregens to its medicinal value.

The principle of the Blair apparatus, by which iodoform is vaporized by heat and forced into root canals, is a correct idea in therapeutics; *i. e.*, the thorough disinfection by the heat required to hold the vapor, and the immediate deposition of the sublimed iodoform, which fills the open spaces, and by its insolubility and *iodic* action on microorganisms, prevents a return of the disease. A thermometer attached to the apparatus would be desirable—together with other improvements—as the compound easily decomposes by heat into free iodine and hydrocarbons, principally ethene, C_2H_2 , $2CHI_3 + q. s. \text{ Heat} = I_6 + C_2H_2$.

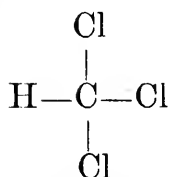
Iodoform is neither a local nor general irritant. Internally exhibited, it is antiseptic, anodyne, stimulant, alterative, and tonic. It is not *wholly* decomposed in the body, as its odor can be detected in the blood and the several tissues.

Dose, 0.06—0.012 Gm. (gr. i-ij)

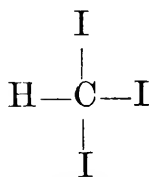
BROMOFORM, *methenyl bromide*, $CHBr_3$, is another haloid ether, analogous to the foregoing compounds, but is not important. To show these bodies, as derivatives of methane, the simplest possible organic chemical *hat-rack* is erected:



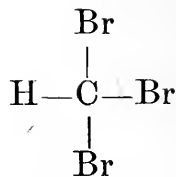
Methane.



Chloroform.



Iodoform.



Bromoform.

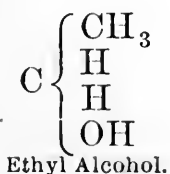
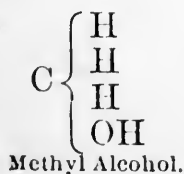
CHAPTER VI.

ALCOHOLS, ETC.

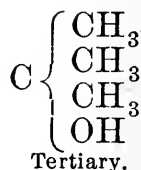
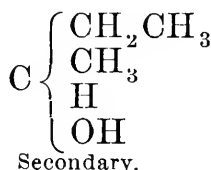
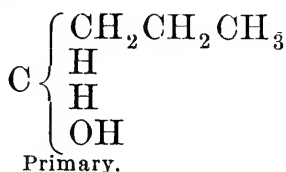
METHYL ALCOHOL, CH_3OH , is known as *wood spirit*, obtained by the dry distillation of wood, and may also be produced by direct synthesis; it is a constituent of oil of winter-green from *gaultheria procumbens*. It is a colorless mobile liquid, of specific gravity 81, which boils at 66° (150°F), and is used as a substitute for ethyl alcohol in various manufacturing processes.

The alcohols are not necessarily similar in physical properties to common alcohol. Some of them are solid, but all may be regarded as consisting of hydrocarbon radicals and hydroxyl.

They are called *monatomic*, when the molecule contains only one group of hydroxyl (OH); and they are known as *primary*, *secondary* and *tertiary*, according as the carbon atom in combination with hydroxyl is also united to one, two or three other carbon atoms.

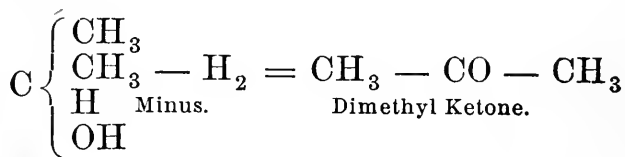


If the hydrocarbon type of the alcohol be preserved, there can be no modification of the first formulas; in other words, there can be no isomeric alcohols of these; but the higher members of the series, as butyl (tetryl, or quartyl), alcohol $C_4H_{10}O$, etc., admit of three modifications, and form three insomeric alcohols, primary, secondary and tertiary.

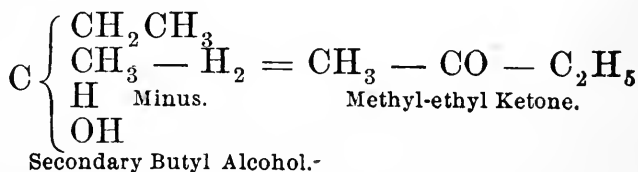


Primary alcohols of the methane series are converted into *aldehydes* by losing 2 atoms of hydrogen, and then by oxidation into corresponding acids.

Secondary alcohols in losing by oxygen, 2 atoms of hydrogen, are converted into *ketones*; as secondary propyl alcohol.

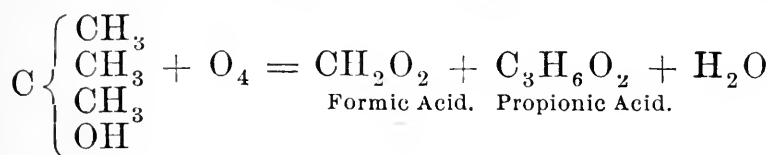


And



Ketones are CO, united to two univalent hydrocarbon radicals.

Tertiary alcohols do not yield either aldehydes, ketones, or acids, containing the same number of carbon atoms as do the alcohols themselves, but are split up into bodies which show a less number of carbon atoms. Thus, with tertiary butyl alcohol:



The following table contains in empirical formulæ, the known monatomic alcohols and corresponding acids, together with acids which have no known alcohol prototypes:

MONOBASIC ACIDS.

GENERAL FORMULA, $C_nH_{2n}O_2$.

{ YIELD. }

PRIMARY ALCOHOLS.

GENERAL FORMULA, $C_nH_{2n+2}O$.

NAME.	Formula.	Boiling Point.	NAME.	Formula.	Boiling Point.	Melting Point.
Methyl	CH_4O	66° C	Formic.	CH_2O_2	100 C	+ 1
Ethyl.	C_2H_6O	78.5	Acetic.	$C_2H_4O_2$	118	17
Propyl.	C_3H_8O	96	Propionic	$C_3H_6O_2$	140	Below 20.
Butyl	$C_4H_{10}O$	109	Butyric	$C_4H_8O_2$	162	20.
Amyl	$C_5H_{12}O$	132	Valerianic.	$C_5H_{10}O_2$	174	18
Hexyl.	$C_6H_{14}O$	150	Caproic	$C_6H_{12}O_2$	199	27
Heptyl	$C_7H_{16}O$	164	Ænanthylic	$C_7H_{14}O_2$	299	43.5
.....	.....	.....	Capric	$C_8H_{16}O_2$	236	53.5
.....	.....	.....	Pelargonic.	$C_9H_{18}O_2$	260	62
.....	.....	.....	Rutic	$C_{10}H_{20}O_2$	.....	..
Decetyl	$C_{10}H_{22}O$	212	Lauroic	$C_{12}H_{24}O_2$	.....	69
.....	.....	.....	Myristic	$C_{14}H_{28}O_2$	.....	75
.....	.....	Melt. Point	Palmitic	$C_{16}H_{32}O_2$	.....	76
Cetyl	$C_{16}H_{34}O$	20	Margaric	$C_{17}H_{34}O_2$	.....	77
.....	.....	.....	Stearic.	$C_{18}H_{36}O_2$	.....	78
.....	.....	.....	Arachic	$C_{20}H_{40}O_2$	.....	88
.....	.....	.....	Behenic.	$C_{22}H_{44}O_2$	.....
.....	.....	.....	Hyænic	$C_{25}H_{50}O_2$	.....
.....	.....	.....	Cerotic	$C_{27}H_{54}O_2$	.....
Ceryl	$C_{27}H_{56}O$	79	Melissic	$C_{30}H_{60}O_2$	.....
Meryl	$C_{30}H_{62}O$	85				

CHAPTER VII.

ETHYL ALCOHOL, ETC.

ETHYL ALCOHOL, C_2H_5OH , is the active principle of brandy, rum, whisky, beer, ale, and wine.

It may be produced by synthetic processes, and by various reactions, but is practically obtained by fermentation of starchy and saccharine substances, such as the different grains, cane sugar, fruits, etc.

The mashed grain in aqueous solution, *ferments* by aid of the yeast germ, the starch being turned into glucose; a weak solution of alcohol is thus obtained.

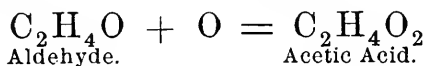
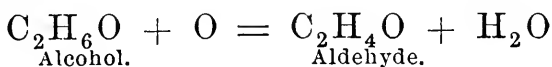


This alcoholic solution is then *distilled*, and the process repeated until about a 90 per cent alcohol is obtained. The water still remaining, is partially removed by distilling with quicklime; the product is then called *absolute* alcohol, a colorless liquid of sp. gr. 80, of a pungent burning taste and spirituous odor. It boils at 78.5C and freezes at -130.5C. Alcohol mixes with water in all proportions; is a solvent for various gums and resins, in

the making of medicinal tinctures, and is used in many chemical and manufacturing processes; it is also a valuable antiseptic against putrefaction and burns in the air, evolving great heat.

Proof spirit contains about 50 per cent of alcohol: whisky, rum and brandy, from 40 to 50 per cent; wines from 5 to 20 per cent, and beer, from 3 to 7 per cent.

Alcoholic or vinous fermentation will run into *acetous* fermentation, unless prevented by *pasteurizing*, by heat or by bottling, or the use of chemicals.



ACET-ALDEHYDE $\text{C}_2\text{H}_4\text{O}$. This compound is the best known of its class, called *aldehydes*. They contain the group COH , and are intermediate between the foregoing alcohols and their corresponding acids.

Acet-aldehyde, also formulated as acetyl hydride, $\text{C}_2\text{H}_3\text{O.H}$, is produced by oxidation of dilute alcohol, and by several other processes. It is a clear liquid of sp. gr. 0.81, at 1° ; of an ethereal suffocating odor, and mixes in all proportions with water, alcohol, and ether. With chlorine it forms acetyl chloride, $\text{CH}_3\text{O.Cl}$; with nascent hydrogen,

alcohol; and with oxygen, acetic acid. It reduces metallic silver from a solution of the nitrate, and unites with the alkali metals, and with ammonia, to form solid compounds, $C_2H_3O.NH_4$. Polymers of aldehyde are known, a doubling and trebling of the molecule, as $C_4H_8O_2$, and $C_6H_{12}O_3$. It is *isomeric* with ethene oxide and acts in many cases as the oxide of a dyad, under the name of *aldehyde*.

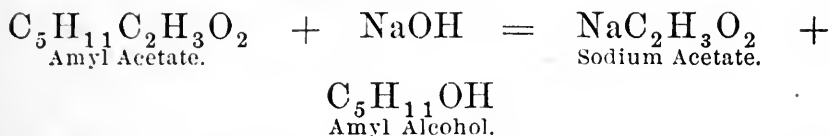
ACETIC ACID, $C_2H_3O_2.H$ (in the dilute state, known as *vinegar*), is the most familiar of the acids corresponding to the methane series of alcohols. The first of this series of acids is *formic acid*, CHO_2H ; next, *acetic*, and so on. With each addition of CH_2 they vary in their physical properties, ranging from the light volatile formic acid, on to, and above, the 9-carbon molecule, where they become semi-solid, of waxy or greasy consistency; hence their general name, *fatty acids*. The best known of these higher acids, are *palmitic*, *margaric*, *stearic* and *mellissic*.

Acetic acid is generally obtained by fermentation (oxidation) of wine, cider, etc., or from the alcoholic *mash* from which spirit is distilled. When pure, it is a colorless liquid which, at a temperature of 18 (64.5F), freezes into a solid; hence the name, *glacial acetic acid*. It mixes in all pro-

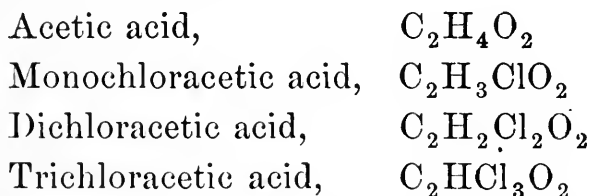
portions with water, alcohol, and ether, and is monobasic, forming, with metallic bases, salts called *acetates*, and with alcohol radicals, such as methyl, ethyl, etc., it forms esters or compound ethers; in these cases, giving up one atom of typical hydrogen to make room for the base, just like similar reactions with the inorganic acids. Acetates of iron and aluminum are used as mordants in calico printing. *Verdigris* is copper acetate; and *sugar of lead* is plumbum acetate, $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 + 3 \text{Aq.}$ The latter compound is of great value to the chemist, and possesses soothing astringent medicinal properties. Calcium carbonate will dissolve in acetic acid (even dilute) forming calcium acetate $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$.

Compound ethers, formed by the fatty acids with the alcohol radicals of the methane series, are becoming quite important as flavoring extracts. The peculiar flavors of fruits are probably due to the presence of these same esters in the substance of the fruits. Amyl acetate, $\text{C}_5\text{H}_{11}\text{C}_2\text{H}_3\text{O}_2$, has the flavor of bananas; ethyl butyrate, $\text{C}_2\text{H}_5\text{C}_4\text{H}_7\text{O}_2$, of pineapples, and amyl valerate, $\text{C}_5\text{H}_{11}\text{C}_5\text{H}_9\text{O}_2$, is known as "apple oil." We may here state, as a matter of some interest, that when organic esters are treated with caustic alkalies the acid radical unites with the alkali metal, and the

typical *alcohol* of the hydrocarbon radical is formed. For example :

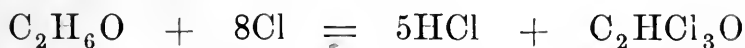


Acetic acid acted upon in different proportions, by chlorine, yields three well-defined *chloracetic* acids, by giving up hydrogen. It is not, however, the hydrogen of the group COOH in the acid, which is replaced by chlorine, as is the case when acted upon by metals.



The *aldehyde* of trichloracetic acid is the liquid chloral, $\text{C}_2\text{HCl}_3\text{O}$, a substance which, united with water, forms the familiar *chloral hydrate*.

Chloral is prepared by prolonged action of chlorine gas on pure ethyl alcohol.



It is a thin, colorless, oily liquid, of little taste, but pungent odor; its sp. gr. is 1.502, it boils at 94° (201F), and is freely soluble in water, alcohol, and ether. Solutions of caustic alkalies decompose it into formate and chloroform.



Chloral forms with water in molecular proportions, *chloral hydrate*, C_2HCl_3O, H_2O , a solid crystalline soluble substance of peculiar odor and sharp, unpleasant taste. It melts at 46° ($114^\circ F$), and boils at 97° ($206^\circ F$).

MATERIA MEDICA.—Locally applied, chloral hydrate possesses sedative, anæsthetic and antiseptic properties, and is assuredly an excellent topical remedy as an ingredient of liniments for the relief of neuralgia and rheumatic pains. Powdered chloral (hydrate) pressed into the alveolar pockets, in pyorrhœ, will serve the double capacity of anodyne and antiseptic. Applied in substance to slightly moistened sensitive dentine, it cuts off, partially, indirect communication with the pulp by extracting moisture from the tubuli; and to the exposed pulp, either alone or combined with camphor, or with aconite tincture, it causes, probably by the same physical change, an immediate lessening of pain. It is of service also in the cure of indolent ulcers in the mouth and other parts.

Taken internally, chloral acts as a sedative to the entire nervous system, and secondarily to the heart. As a hypnotic, it reduces the blood pressure on the brain, and thus induces sleep by imitating the natural anatomical phenomenon of that process, and by diminishing at the same time the conductivity

of the sensory nerves. Awakening is not accompanied by the digestive disturbances, nausea, and headache, which usually result from the use of opium.

In full doses chloral slows the heart's action and respiration, and lowers the temperature. It may cause death by either syncope, or coma, and those addicted to the chloral *habit* often suffer with scorbutic sores and ulceration of the gums.

Dose: 0.30 – 1.25 Gm (gr. v – xx).

R. Chloral hydratis.

Pot. Bromide, aa 0.65 Gm (gr. x).

Syrupi aurantii cort.

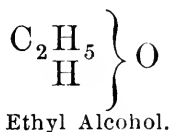
Aq. menth pip. aa 15.00 f Gm (f ̄ss).

M. S. A hypnotic potion in acute alveolar abscess.

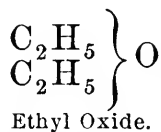
CHAPTER VIII.

ETHERS, ETC.

OXYGEN ETHERS are defined as alcohols (typical), with the hydroxyllic hydrogen replaced by an alcohol radical. Thus:

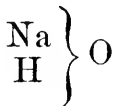
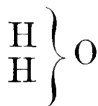


Ethyl Alcohol.

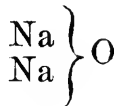


Ethyl Oxide.

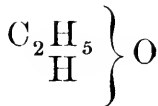
They may also be regarded as bearing the same relation to the alcohols that metallic oxides bear to the metallic hydrates, and all belong to the water type.



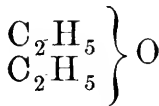
Sodium Hydrate.



Sodium Oxide.

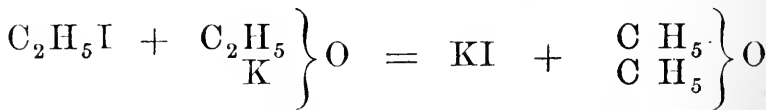


Ethyl Alcohol.



Ethyl Oxide.

ETHYL OXIDE $(\text{C}_2\text{H}_5)_2\text{O}$, *common ether*, known also as sulphuric ether, can be obtained from a large number of *ethyl* compounds, as for instance:



Ethyl Iodide.

Pot. Ethylate.

Ethyl Ether.

Practically, ether is obtained from ethyl alcohol by the dihydrating influence of sulphuric acid, at the proper temperature :



Ether is a clear mobile liquid of a strong, though not unpleasant odor, and a warm penetrating taste. Its specific gravity is 0.730. It is not readily soluble in water, and is not as good a general solvent as chloroform. Its boiling point is dangerously low, 35.5° (96F), and at still lower temperatures it evaporates rapidly; the vapor is about two and a half times as heavy as air, and is highly inflammable. If ether be freely exposed to the air, it tends to oxidize into acetic acid.

MATERIA MEDICA.—Inasmuch as the rapid abstraction of heat from a part reduces sensibility, the *local* employment of ether in the form of spray, on account of its volatility, has been favored to some extent in the operation of extracting teeth.

Ether internally administered in the form of Hoffmann's anodyne, which is a compound of ether, alcohol, and ethereal oil, is antispasmodic, stimulant, and carminative; in the preparation known as *spirits of nitrous ether*, composed of alcohol and ethyl-nitrite ($\text{C}_2\text{H}_5\text{NO}_2$), it is an excellent diuretic and diaphoretic, in fevers.

The first practical use of ether as a general anæsthetic was made by Dr. Morton, a dentist of Boston, in 1846.

Although much slower in its immediate effects, ether is considered a safer anæsthetic than chloroform; the stimulus to the heart is more pronounced, and continuous than with chloroform, albeit, ether should not be exhibited no more than other anæsthetics wherever decided weakness of the heart, lungs, or brain, is seriously suspected.

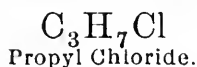
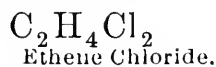
In *ether narcosis*, the cerebrum seems to be the first of the nerve centers involved; then the sensory, followed by the motor centers, of the cord; and finally the sensory and motor functions of the medulla oblongata; thus, in the later stages inducing a slowing of both the heart's action and respiration. The time required for complete etherization, is from three to five minutes, and the quantity of ether, about 60.00 Gm (3ij).

We may here place on record merely as a fact, and not in any degree as encouraging to dental quackery, the composition of so-called *vitalized air*. To one gallon of nitrous oxide gas, is added three drops of an equal mixture of alcohol and chloroform.

Ethyl chloride, C_2H_5Cl , on account of its tendency to induce excessive cold by rapid evaporation,

has been employed as a local anæsthetic for sensitive dentine, etc.

Chlorine forms with the different series of homologous hydrocarbons, a *new* homologous series in each case; each member differing from the next, by CH_2 , and containing equivalent chlorine as a substitute for hydrogen.

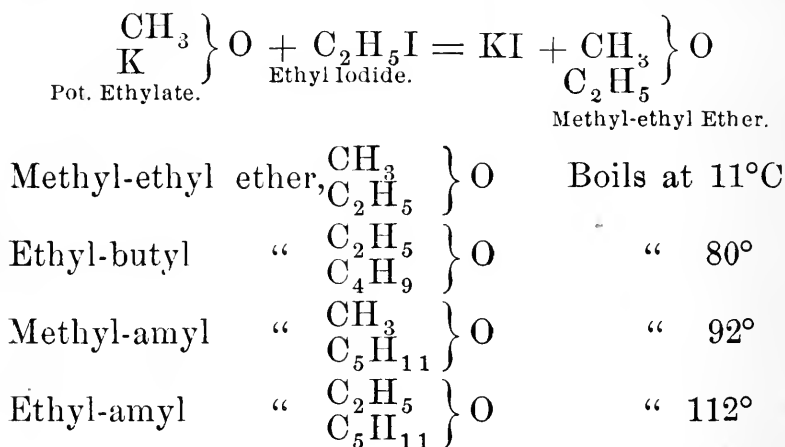


The density of these haloid ethers, increase in regular gradation, by each addition of CH_2 , just like the typical saturated hydrocarbons. Indeed, we can almost realize in every instance, the physical properties of organic compounds, by observing their molecular weights, as to whether they are gaseous, liquid, or solid, and in every instance the *vapor* density of the substance, compared with hydrogen, is ascertained by dividing its molecular weight by 2.

Thus methyl chloride, CH_3Cl , is a gas 25 times as heavy as hydrogen, a little more than one and a half times as heavy as air. Ethyl chloride, $\text{C}_2\text{H}_5\text{Cl}$, is a light liquid, the vapor of which is two and a half times as heavy as air; and ethyl bromide, $\text{C}_2\text{H}_5\text{Br}$, is a liquid almost twice as heavy as water, although

it boils at a lower temperature, 72 (163F.) Its vapor density is nearly four times that of the atmosphere.

Mixed oxygen ethers contain two different alcohol radicals, united to hydroxylic oxygen. They are produced by various reactions, as for example :



The other alcohols of the methane series, aside from those already alluded to (methyl and ethyl alcohols), and amyl alcohol, are interesting to us only as chemical curiosities.

BUTYL and PROPYL alcohols, and those following, are susceptible of isomeric modifications. *Cetyl alcohol*, $\text{C}_{16}\text{H}_{33}\text{OH}$, is characteristic of *spermaceta*; and *metyl alcohol*, $\text{C}_{30}\text{H}_{61}\text{OH}$, is a necessary constituent of beeswax. These alcohols are solid.

Spermaceta and beeswax are really compound ethers, or esters, formed by alcohol radicals, united respectively to palmitic and melissic acids.

AMYL ALCOHOL, *pentyl alcohol*, $C_5H_{11}OH$, is the chief constituent of fusel oil, and occurs as a residue, after distillation of ethyl alcohol, especially from the starch of potatoes. When pure, amyl alcohol is a colorless liquid, of unpleasant burning odor and acrid taste. Its specific gravity at 0° is 0.825. It boils at 130 ($266F$), and freezes at -20° . It changes by oxidation into valeric acid.

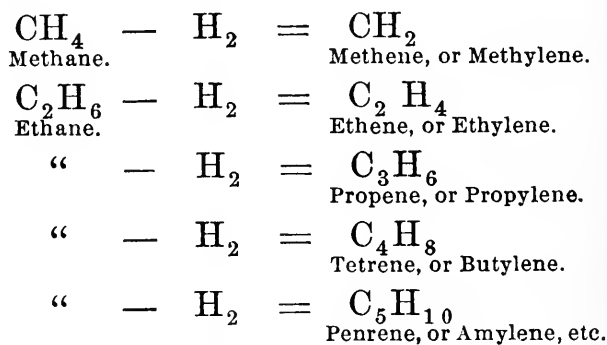
Amyl acetate, $\left. \begin{matrix} C_5H_{11} \\ C_2H_3O \end{matrix} \right\} O$, as its name suggests, is an amyl ester which, on account of its pear-like odor, is used in flavoring cheap confectionery.

AMYL NITRITE, $C_5H_{11}NO_2$, is also a compound ether, obtained by action of nitric acid on amyl alcohol; is a yellow colored oily liquid, of sp. gr. 0.877, volatile, and inflammable; boils at 83 ($182F$), and emits a persistent diffusive odor of ripe pears. In materia medica this ether is known as *amyl nitris*, and is used as a stimulant to the heart, in case of ordinary syncope or excessive anæsthetic narcosis. The vapor from 2 or 3 drops, inhaled from a napkin, produces immediate *flushing* in the face, dilatation of the arterial system and rapid pulsation and breathing. If pushed too far, the symptoms of carbon dioxide coma supervene. Its employment with anæmiac patients is safer than with those of plethoric habit.

CHAPTER IX.

OLEFINES, ETC.

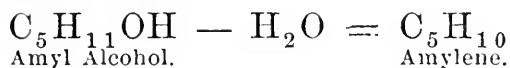
The homologous hydrocarbon series C_nH_{2n} , next isologous to the paraffins, are simple multiples of CH_2 . They are dyad radicals, produced by abstraction of two atoms of hydrogen from the saturated paraffins. Thus—



These dyad hydrocarbon radicals are known as *olefines*, from the fact that the most important member of the series, ethene C_2H_4 , forms with chlorine, an oily liquid, $C_2H_4Cl_2$.

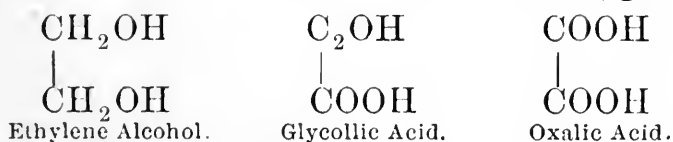
The first free members of the series, ethylene and propylene, are *gases*; butylene is an exceedingly volatile *liquid*, which boils at 3° ($37^\circ F$), and amylene also, which boils at 35° ($95^\circ F$); the higher members of the series, as melene, $C_{30}H_{60}$, are solid.

The olefines may be formed by various reactions, only one of which we will mention, *i. e.*, the abstraction of water, from corresponding monatomic alcohols (methane series), by powerful dehydrating agents, such as sulphuric acid, zinc chloride, or phosphoric oxide. Thus—



The alcohols of the olefine series are diatomic, as ethylene alcohol, $\text{C}_2\text{H}_4(\text{OH})_2$. They are called *glycols* because they are intermediate in the series belonging to ordinary alcohol, and the series of triatomic alcohols, of which latter *glycerine*, $\text{C}_3\text{H}_5(\text{OH})_3$, is the best known.

DIATOMIC ALCOHOLS, *glycols*, produce by oxidation, two series of acids, monobasic and disbasic, respectively. The first is derived by replacing 2 atoms of hydrogen, in ethylene, for instance, by 1 atom of oxygen, and the second by replacement of all 4 atoms of hydrogen by 2 atoms of oxygen.



The acids of the glycollic series having but one group of COOH are monobasic; those of the oxalic series are dibasic. Accordingly we have the glycollic, or lactic acid series:

Carbonic acid, CH_2O_3

Glycollic acid, $\text{C}_2\text{H}_4\text{O}_3$

Lactic acid, $\text{C}_3\text{H}_6\text{O}_3$

Butylactic acid, $\text{C}_4\text{H}_8\text{O}_3$

Valerolactic acid, $\text{C}_5\text{H}_{10}\text{O}_3$

And the oxalic series:

Oxalic acid, $\text{C}_2\text{H}_2\text{O}_4$

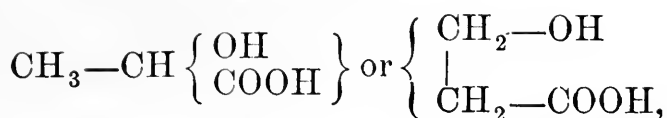
Malonic acid, $\text{C}_3\text{H}_4\text{O}_4$

Succinic acid, $\text{C}_4\text{H}_6\text{O}_4$

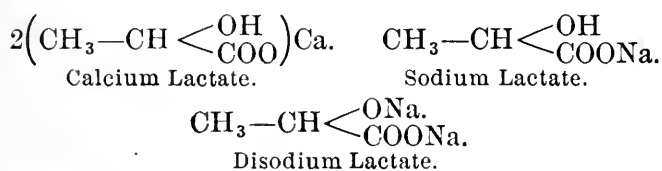
Pyrotartaric acid, $\text{C}_5\text{H}_8\text{O}_4$, etc.

LACTIC ACID is the characteristic acid of sour milk. It is formed also by lactic fermentation of glucose, and starch, and many other vegetable products by the influence of several bacteria, the special microbe *penicillium glaucum* being probably the most characteristic. The acid is now extensively prepared by supplying a pure culture of lactic ferment to glucose obtained from corn starch. It can also be obtained artificially, by direct oxidation of propylene glycol, $\text{C}_3\text{H}_6(\text{OH})_2 + \text{O}_2 = \text{H}_2\text{O} + \text{C}_3\text{H}_6\text{O}_3$, and by various other chemical processes. It is found in the stomach and small intestines; the flesh of animals also contain an isomeric modification, called para-lactic acid. All the salts of lactic acid are soluble in water and alcohol, insoluble in ether.

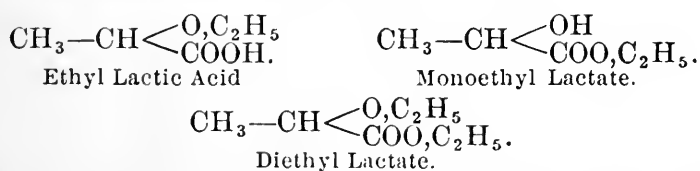
Lactic acid is a heavy liquid of specific gravity 1.215; it is highly *hygroscopic* and is soluble in water, alcohol, and ether. The formula:



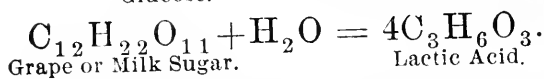
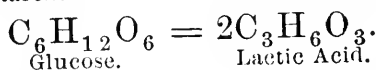
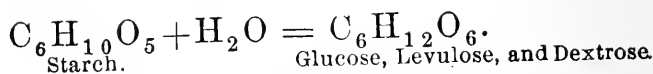
will enable us to understand the reactions that may occur between lactic acid, and positive radicals. With metals such as zinc, and calcium, it is only the hydrogen of the group COOH that gives its place to the metal; the metals of the alkalis however are capable of removing likewise, the hydroxylic hydrogen. In this connection the following formulas are suggestive:



Hydrocarbon radicals can displace either the alcoholic hydrogen, or the basic hydrogen, or both, in the lactic series of acids, and these acids therefore, can form three different ethers. As,



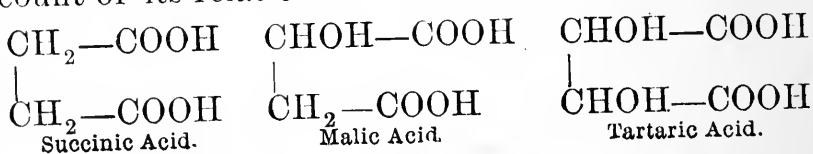
The principal exciting cause of caries of the teeth, has been generally accepted, since the published experiments of Prof. W. D. Miller, as due to lactic fermentation in the mouth. Food *carbohydrates*, amylaceous, and saccharine, are especially disposed to this form of fermentation,



Free lactic acid destroys the bacteria that produce the fermentation ; but the acid as it develops in the cavity of decay, is at once neutralized at the expense of the mineral portion of the tooth structure, calcium lactate, $\text{Ca}(\text{C}_3\text{H}_5\text{O}_3)_2$, being formed, which permits a continuation of the process.

OXALIC ACID, $\text{C}_2\text{H}_2\text{O}_4$, is the characteristic acid of *wood sorrel* and *rhubarb*. When evaporated from solution, it occurs in prismatic crystals, resembling magnesium sulphate, but very poisonous. It may be produced artificially, by oxidizing starch or sugar, with nitric acid, and is now largely manufactured from sawdust.

Oxalic is the first of a long homologous series of acids ; the immediate succeeding members are given on page 292. They are all dibasic, and can therefore form both normal and hydrogen salts. Of these, succinic acid is the most interesting on account of its relation to malic and tartaric acids.



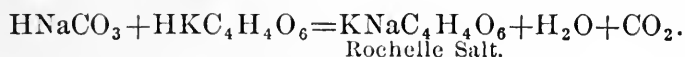
Malic is the acid of apples, and certain other fruits and vegetables, it occurs in white soluble crystals.

Tartaric acid exists in the juice of grapes, tamarind, etc. During the fermentation of wine, potassium tartrate is deposited on the sides of the wine casks; hence the name *tartar*, is given to deposits on the teeth.

Tartaric acid occurs as a white crystalline substance, of very sour taste. It forms the contents of one of the papers, in Seidlitz powder; the other paper containing a mixture of hydrosodium carbonate and potassium sodium tartrate. On solution in water, effervescence, by the escape of CO_2 , takes place.

Cream of tartar, is hydrogen-potassium tartrate, $\left. \begin{smallmatrix} \text{H} \\ \text{K} \end{smallmatrix} \right\} \text{C}_4\text{H}_4\text{O}_6$; the best varieties of *baking-powders*, are mixtures of cream of tartar, and hydrogen sodium carbonate (bicarbonate of soda).

The moisture of the dough, when heated induces the following reaction:

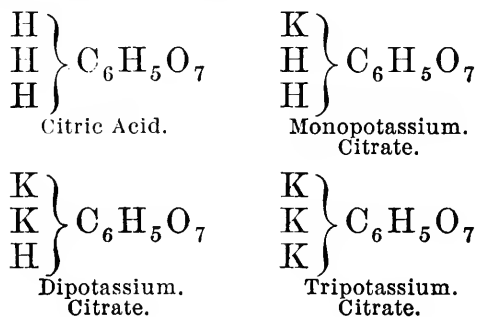


The escaping CO_2 , *raises* the dough, thus conferring lightness; the Rochelle salt remains with the bread.

Tartar emetic is tartrate of potassium and antimony, $\left. \begin{smallmatrix} \text{K} \\ \text{SbO} \end{smallmatrix} \right\} \text{C}_4\text{H}_4\text{O}_6$, used more or less in medicine, as an emetic.

Citric acid, $\text{C}_6\text{H}_8\text{O}_7$, although not related to the above, is also a fruit acid, being found in the juice of oranges and lemons; and in other fruits, as gooseberry, currant, etc., in company with malic acid.

This acid is tribasic, as may be seen by the subjoined condensed formulæ :



CHAPTER X.

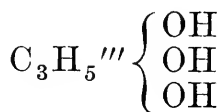
FATTY ACIDS, ETC.

By reference to the table of corresponding alcohols and acids on page 276, it will be seen that the solid acids, named palmitic, margaric and stearic belong to the group of monobasic *fatty* acids. *Palmitic acid*, $C_{16}H_{32}O_2$, occurs as an ether of propenyl, in many natural fats, and in palm oil; also in *cetin* of spermaceti, and in *melissin* of beeswax. It is a solid, lighter than water; it melts at 62° ($144^\circ F$), and when heated with alcohols, yields compound ethers. *Margaric acid*, $C_{17}H_{34}O_2$, is intermediate between palmitic and *stearic* acids. The latter acid, $C_{18}H_{36}O_2$, occurs in the more solid fats of animals; also in the softer fats, as butter and goose grease, and in some of the fats of vegetable origin, as in cocoa butter. Stearic acid is a solid, a little heavier than water; it melts at 69° ($162^\circ F$) and distils without alteration.

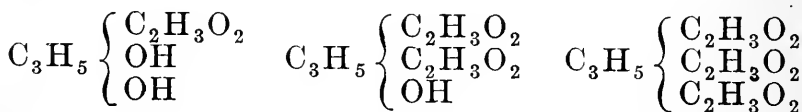
Oleic acid, $C_{18}H_{34}O_2$, is monobasic, but belongs to another series of acids, having the general formula, $C_nH_{2n-2}O_2$. It is the fluid constituent of most natural fats and fixed oils; it solidifies at

4° (39F), and is, therefore, liquid at common temperatures; its specific gravity is 0.898. These fatty acids are found in nature as ethers of the radical *propenyl*, C_3H_5''' .

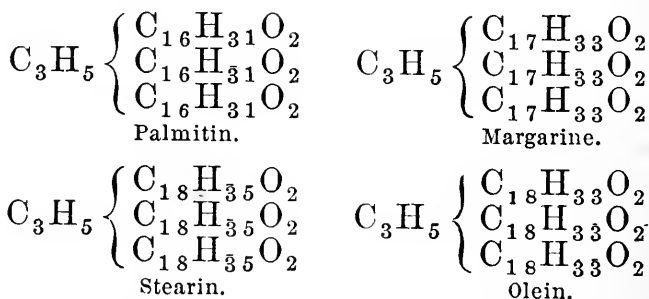
GLYCERINE, *Glycerol*, is propenyl alcohol, and as propenyl, is a triad radical, the alcohol in question must be triatomic.



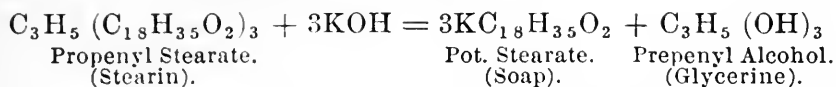
With some monobasic acids, therefore, this alcohol may form three distinct ethers, as with acetic acid :



The natural oils and fats are generally found as triple (normal) ethers of palmitic, margaric, stearic and oleic acids :

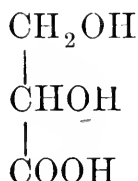


When these fatty ethers are saponified by alkalis, a salt of the alkali metal (soap) is formed, and propenyl alcohol thus set free.



Glycerine is also produced in small quantity in sugar fermentation, and is now separated largely from the fats, by high pressure steam.

When acted on by dilute nitric acid, glycerine exchanges 2 atoms of hydrogen for O, forming glyceric acid.



When treated with strong nitric and sulphuric acids, glycerine yields the explosive compound known as *nitro-glycerine*, $\text{C}_3\text{H}_5 (\text{NO}_3)_3$. This propenyl-nitrate is a thick oily liquid; it burns quietly, but if struck fiercely or ignited by a *fulminate*, it explodes with frightful violence. It is the basis of different varieties of *dynamite*, which consists of absorbed nitro-glycerine in infusorial earth or sawdust, etc., to a porous pasty solid, of less danger in handling than the liquid.

Glycerine itself is a syrupy liquid of sp. gr. 127, is nearly colorless, and of sweetish taste. When pure, it is said to boil at the high temperature of 290° (554°F), a fact which suggested its employment in an open dish for vulcanizing rubber, to avoid the danger attending the ordinary method.

Commercial glycerine contains too much water to permit a sufficient elevation of temperature for the purpose, and even where the pure variety is used, acrid vapors consisting of *acrolein*, C_3H_4O , are given off, the same as from the wick of an imperfectly quenched candle.

MATERIA MEDICA.—Glycerine is soluble in water and alcohol; insoluble in chloroform and ether. It is a good solvent for various drugs, such as tannin, creosote, carbolic acid, iodine, borax, quinine, etc. It is antiseptic and soothing, and is applied as an emollient to sore or inflamed surfaces, either alone or as a vehicle adjunct for other remedies, as in the following *Glycerita*:

Glycerina, . 30.00 fGm. (f3i)

Acidi Tannici, 8.00 Gm. (3ij)

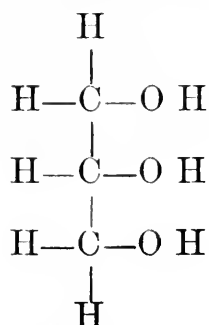
Glycerina, . 30.00 fGm. (f3i)

Acidi Carbolici, 8.00 fGm. (f3ij)

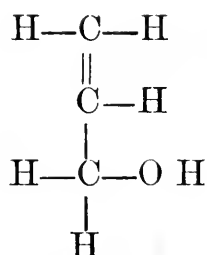
Glycerina, . 30.00 fGm. (f3i)

Sodii Biboras, . 8.00 Gm. (3ij)

The univalent radical *allyl*, C_3H_5 , is isomeric with the trivalent radical of glycerine, propenyl. They differ in structure, however, as the following formulas will show:



Glycerol.



Allyl Alcohol.

The natural oil of garlic owes its pungency to allyl sulphide $(\text{C}_3\text{H}_5)_2\text{S}$; the oil of mustard, to allyl sulphocyanate, $\text{C}_3\text{H}_5\text{CNS}$.

CHAPTER XI.

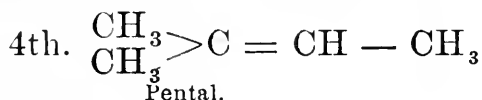
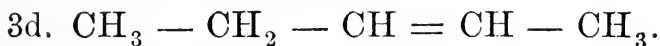
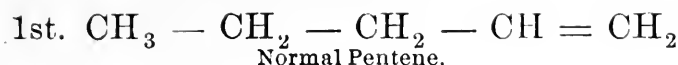
AMYLENE, ETC.

We have alluded to the olefines, dyad hydrocarbons of the general formula, C_nH_{2n} , and stated that one source of their derivation is by dehydrating the alcohol of the same number of carbon atoms. Thus, *isopentene* (amylene), C_5H_{10} , is obtained by action of dehydrating agents, such as sulphuric acid, zinc chloride, phosphoric oxide, etc., on pentyl (amyl) alcohol,

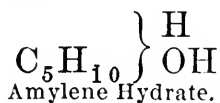


The formula, C_5H_{10} , is capable of four modifications. *Normal* pentene, sometimes regarded as ethyl-allyl, C_2H_5, C_3H_5 , is obtained by action of sodium on mixed ethyl and allyl iodides. The third possible modification is not well known, while the fourth variation, is probably identical with the new anæsthetic called *pental*.

These possible variations of C_5H_{10} are represented below :



Pental is said to be produced from amylene hydrate (amylene alcohol), by heating in the presence of acids. This hydrate is isomeric with amyl alcohol. They differ, however, in certain properties, and therefore must differ in structure.



If these two alcohols be acted on by the same dehydrating agent, the resulting compounds would differ in some of their properties. They must, however, have the same vapor density. The boiling points of normal pentene, isopentene (amylene), and pental, approximate $35^\circ\text{--}38^\circ$ ($95\text{--}104^\circ\text{F}$), and probably vary in this respect, only on account of difference in absolute purity. Their specific gravities also approximate $0.663\text{--}0.6783$. They are insoluble in water, but mix freely in ether, chloroform, and alcohol. They are exceedingly volatile and inflammable, and their vapor, when inhaled, causes insensibility to pain.

Amylene was introduced as an anæsthetic in 1856, but made slight impression. *Pental* was introduced to the profession in this country, in 1891. Its odor somewhat resembles that of mustard oil, suggesting the radical *allyl*.

The claims made for pental as an anæsthetic in dental operations, are :

To reach narcosis, requires but from 1–3 minutes.

Heart's action and respiration are not materially interfered with.

There is no spasm of the muscles.

The narcosis is brief, and the patient recovers without any accompanying headache, nausea or vomitings. Nevertheless, pental has not been received thus far with as much favor as its friends think it deserves.

The series of hydrocarbons, C_nH_{2n-2} , of which Ethine (acetylene), C_2H_2 , is the only important member, belong to the fatty compounds, like the paraffins and alefines, as distinguished from the aromatic compounds. The first two numbers are gases; the others increasing in density through liquid and solid states, by each additional CH_2 .

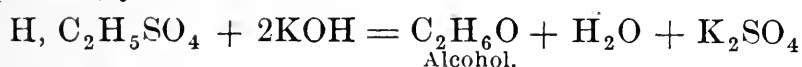
Acetylene, C_2H_2 , is a constituent of coal gas, on which it confers, largely, a disagreeable odor. It may be produced by various decompositions of organic compounds, but it is especially distin-

guished as the only compound, formed synthetically by direct union of carbon and hydrogen.

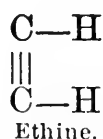
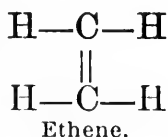
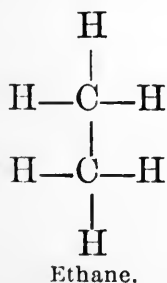
When a strong electric *arc* current is passed from carbon poles through an atmosphere of hydrogen, the carbon, as it volatilizes, unites with the hydrogen, $2\text{H} + 2\text{C} = \text{C}_2\text{H}_2$.

From acetylene, a great number of organic compounds can be obtained. Thus, by aid of platinum black, it will take up 2 atoms of hydrogen to form ethylene, C_2H_4 , $\text{C}_2\text{H}_2 + \text{H}_2 = \text{C}_2\text{H}_4$.

Ethylene combines with concentrated sulphuric acid to form basic ethyl-sulphate, $\text{C}_2\text{H}_4 + \text{H}_2\text{SO}_4 = \text{H}, \text{C}_2\text{H}_5\text{SO}_4$, and this, when heated with caustic potash, yields as follows:



In ethane, C_2H_6 , the 2 carbon atoms are united by 1 bond, in ethene (ethylene (C_2H_4), the carbon atoms are united by 2 bonds, and in ethine (acetylene) the carbon atoms are united by 3 bonds, thus:

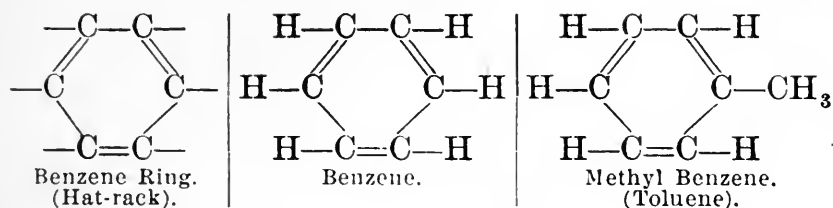


The hydrocarbons of the general formula, $\text{C}_n\text{H}_{2n+2}$

H_{2n-6} , are represented by the first member of the series, *Benzene*, C_6H_6 , (not the petroleum product, *Benzine*); the second member *Toluene*, C_7H_8 , is also frequently miscalled benzol and toluol. The other members of the group, are susceptible of isomeric modifications, and they all belong to the *Aromatic* series of hydrocarbons, so named because many derivatives of benzene, such as benzoic acid, oil of bitter almonds, etc., possesses a fragrant odor.

Benzene, C_6H_6 is chiefly obtained from the coal tar of the gas-works. It is a light highly inflammable liquid, which boils at 80° ($176^\circ F.$) and freezes at 3° ($37^\circ F.$); it is soluble in alcohol and ether, scarcely so in water, has an ethereal odor, and is produced largely, for the manufacture of aniline dyes.

The six carbon atoms in benzene, form a *closed ring*; they are united by 1 and 2 bonds, alternately, permitting one bond, belonging to each atom to remain free, forming thus a quasi *hat-rack*, which is capable of receiving alternately, innumerable elementary or compound univalent radicals; so the derivatives of benzene may be considered practically illimitable, and thousands of them are already known.



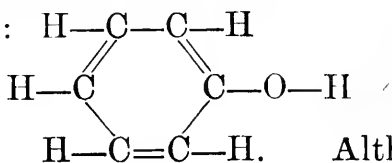
Groups of compound radicals like CH_3 attached to the nucleus ring, in the place of H, form *lateral* chains, which themselves may give up H, to form substitution derivatives.

The homologues of benzene, as toluene, etc., ($\text{C}_6\text{H}_6 + \text{CH}_2$, etc.), may be derived by substitution of methyl, CH_3 , for one or more of the six hydrogen atoms; and where but one hydrogen atom is removed from benzene, the compound radical *phenyl*, C_5H_5 , is presented.

Benzene itself, is the *hexune* of Hoffmann; and its homologues are isologous with many hydrocarbons of great interest, and practical use, such as cinnamene, C_8H_8 , naphthalene, C_{10}H_8 , and anthracene, $\text{C}_{14}\text{H}_{10}$, and the terpenes, $\text{C}_{10}\text{H}_{16}$.

Phenyl alcohol, $\text{C}_6\text{H}_5\text{OH}$, commonly called carbolic acid, is usually obtained from coal tar by distillation, between the temperatures of 150° and 200° ($302\text{--}392\text{F.}$) It is also produced by various other methods of reaction on benzene derivatives, and by dry distillation of organized complex substances, such as coal and wood.

This phenol shows its relation to benzene, by the graphic formula:



Although not an acid, it takes its name as such, because it forms salts with the alkalies, such as potassium phenate $\text{C}_6\text{H}_5\text{OK}$, by giving up its hydroxylic hydrogen to the metal. This reaction however suggests an alcohol, and moreover, carbolic acid forms, like the alcohols, compound ethers, such as methyl phenate $\text{C}_6\text{H}_5\text{—O—CH}_3$, (*anisol*), and ethyl phenate $\text{C}_6\text{H}_5\text{—O—C}_2\text{H}_5$, (*phenetol*), etc.

MATERIA MEDICA.—*Phenyl alcohol, carbolic acid, phenic acid*, simply *phenol*, when pure, occurs in clear prismatic needles of specific gravity 1.066; it melts at 40° (104°F), and boils at 181° (357°F). It possesses a smoky odor and burning taste. It forms a complete aqueous solution with 95 per cent of water, and will *liquefy* by the presence of 5 per cent of water.

It acts as a local anæsthetic when applied to soft parts, as the dental pulp, probably by forming, with albuminoids, a protecting coagulum. It acts as a superficial caustic when applied undiluted, and is one of the best antiseptics, so long as the *coagulum*, which it forms with the substance of the

tissue acted on, or with the substance of bacteria themselves, remains undissolved.

When dissolved in chloroform, ether, or alcohol, the caustic properties of carbolic acid are enhanced; it also dissolves in the essential oils and in glycerine, which somewhat diminish its causticity. It is an active poison.

Dose, 0.06 Gm. (grj) in solution, or pill.

Antidotes, olive oil and saccharated lime.

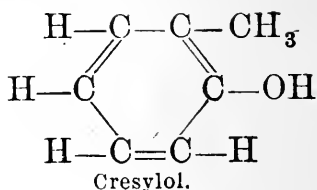
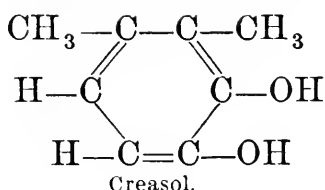
Robinson's Remedy, composed of equal parts of carbolic acid and caustic potash, is useful in alveolar pyorrhœa, and with arsenic, for destroying dental pulps.

Phenol Sodique is a solution in water of 5 parts carbolic acid and 1 part of caustic soda, useful as an ingredient of antiseptic mouth washes. Phenol trichloride is antiseptic and a powerful disinfectant.

R.	Acida carbolici,	2.00	Gm.	(3ss)
	Glycerini,	10.00	fGm.	(f3ijss)
	Aq. Rosæ q. s. ad.,	120.00	fGm.	(f3iv)

M. S. Antiseptic solution.

CREASOTE is a product of the distillation of wood tar, and is a mixture of several phenols, such as carbolic acid, creasol, $C_8H_{10}O_2$, and cresylol, C_7H_8O . These latter may also be attached to the benzene *hat-rack*:



Creasote is an oily liquid of specific gravity 1.08. It possesses a caustic burning taste, and a penetrating empyreumatic odor. On long exposure to light, it turns to a reddish yellow. It mixes in all proportions with ether, alcohol, acetic acid, and naphtha, but not with glycerine. With water it forms two solutions, 1 part creasote to 80 of water, and 10 parts creasote to 1 of water. It may be distinguished from carbolic acid by producing a green instead of a brown color, with alcoholic solution of ferric chloride.

Creasote possesses many of the virtues of carbolic acid. It is antiseptic, anæsthetic, escharotic, and styptic. When applied to exposed dental pulp, it effectually relieves the pain; and when diluted, it is useful as an application to ulcerative conditions of the skin and mucous membrane. It is preferred to carbolic acid as an internal remedy in phthisis, nausea, cholera, and passive hemorrhage.

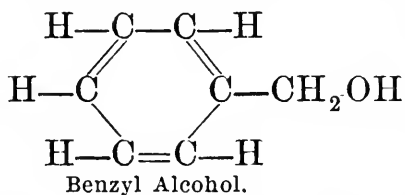
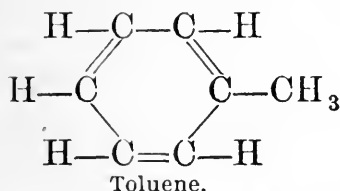
Dose, 0.06–0.12 fGm. (m̄j–ij)

Antidotes, same as carbolic acid.

CHAPTER XII.

BENZENE GROUP.

The aromatic alcohols of the benzene homologues, are formed by substitution of OH for H in the lateral chains, and contain the group CH_2OH . As,

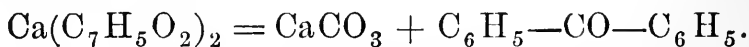


They are therefore primary alcohols. They change to aldehydes, and acids, by oxidation, and yield ethers, analogous to those of the monatomic alcohols.

BENZOIC ACID, $\text{C}_6\text{H}_5\text{COOH}$, is characteristic of the urine of herbivorous animals. It exists already formed in certain balsams and gum resins, as in *gum-benzoin*, which exudes from the *Styrax Benzoin* tree of Borneo, and adjacent countries. It may also be obtained by various reactions on many benzene derivatives. It is an inodorous solid, but when warm, emits a faint agreeable odor; it melts at 120° (248F.) and boils at 250° (482F.); is freely soluble in alcohol but sparingly so in water. Its

salts called *benzoates* are generally soluble in water and have the formula, $MC_7H_5O_2$.

Calcium benzoate is changed by dry distillation into calcium carbonate and *benzone*, or the ketone of benzoic acid.



Benzoic acid is a good germicide and antiseptic, and is stimulant to mucous surfaces. It is probably the most active ingredient of the antiseptic mixture known as *Listerine*, and is also one of the ingredients of "*Harris' Gum Wash*." It is used internally in gout, calculi, inflammation of the bladder, and incontinence of urine.

Dose, 0.50 Gm. (gr. vij.)

Benzoin tinctures, are effective in treatment of ulcerative inflammation of the oral mucous membrane, and of sloughing wounds.

Ammonium benzoate, $NH_4C_7H_5O_2$, is antacid and stimulant, and is acceptable to the stomach, in acid dyspepsia.

The new substance, *saccharine*, which is said to possess 300 times the sweetening power of cane sugar, is a derivative of benzoic acid. It is the *anhydride* of orthosulphamidobenzoic acid.

Benzaldehyde, is the familiar fragrant oil of bitter almonds.

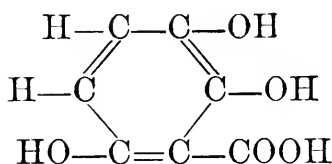
Salicylic acid, $C_6H_4 \begin{smallmatrix} \text{OH} \\ \text{COOH} \end{smallmatrix}$, occurs in salicin, of

the willow and poplar, and free, in the flowers of meadow-sweet; and as mythylic ether, in oil of wintergreen (*Gaultheria procumbens*), from which it may be obtained by distillation with potash. It is however principally prepared by heating sodium phenate with carbon dioxide.

Salicylic acid appears as a white crystalline powder, freely soluble in glycerine, alcohol, and ether, sparingly soluble in water; is without odor, or taste, but leaves a sweet astringent aftertaste; it is resolved, by heating with pounded glass, into carbon dioxide, and phenol. It is an excellent antiseptic, and is somewhat disinfectant, and is frequently employed with good results, in powder or ethereal solution, as a dressing in suppurating root canal; and in alcoholic solution with borax, in treatment of aphthæ, and other inflammatory conditions of the mouth. Mild alkalies, as borax and sodii phosphas, increase its solubility. It is affective as a deodorizing dentifrice, when combined in proper proportion with suitable vehicles; when in strong solution, its acid nature is objectionable to the teeth.

Dose, 0.50–1.25 Gm. (gr. viij–xx.)

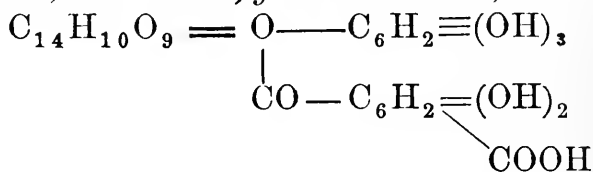
GALLIC ACID, dioxysalicylic acid, trioxybenzoic acid, $C_7H_6O_5$, may be also erected on the benzene ring.



Gallic acid is a constituent of nut galls, and many other vegetable bodies, but is most conveniently prepared from tannin. It is acid in reaction, is only slightly soluble in cold water, but freely soluble in hot water, and in alcohol, ether, and glycerine. It possesses astringent and styptic properties.

Dose, 0.10–0.30 Gm. (gr.ij–v.)

TANNIN, *tannic acid*, *gallotannic acid*,



Ordinary tannic acid is obtained from *nut galls*, which are produced as an excrescence on the young twigs of the species of oak known as the *quercus infectoria*, by the puncture of the insect *cynips gallæ tinctoriæ*. The galls are irregularly rounded and tuberculated nuts, from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch in diameter, of a green gray color, and of decidedly astringent taste. The favorite galls, come chiefly from the Levant. They are rich in tannic, and gallic acids.

Medicinal tannin, is obtained from powdered galls by the action of commercial ether. It is a feathery

amorphous powder, of a light yellow color, soluble in water, glycerine, alcohol, and ether. It produces *coagula* with gelatine and albumen, and *precipitates* with vegetable alkaloids, and with ferric compounds. These substances are therefore incompatible with tannin.

MATERIA MEDICA. Locally applied tannic acid is especially astringent. It is therefore suggested as a good local application in inflammations of the mucous membrane, in either one of the extreme portions of the *prima via*. In passive hemorrhage, sometimes excessive, after the extraction of teeth, pledgets of cotton wool, holding tannin en masse, inserted into the bleeding sockets of the alveoli, will nearly always effectually arrest the hemorrhage, by its astringent action on the vessels, and by its coagulating effect on the albumen of the escaping blood.

Internally, tannin combinations, are frequently exhibited in diarrhœa, cholera, and hemorrhage.

Dose 0.06-0.18 Gm. (gr.j-ij.)

R. Acidi Tannici 4.00 Gm. (ʒi).

Glycerinæ.

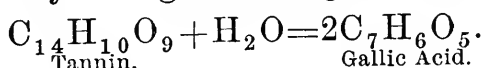
Aqua Dest. aa 15.00 fGm (fʒss).

M. S. Apply in nursing sore mouth.

The tannins are the active astringent principles of various vegetable bodies, such as krameria, catechu, kino, hæmatoxylon, hamamelis, or witch-

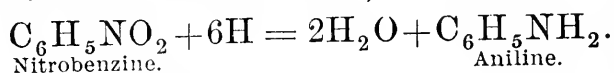
hazel, and of *quercus alba*, and other species of oak. They are denominated *glucosides* because like amygdalin, coniferin, salicin, etc., they change by the action of ferments, or by dilute acids, or alkalies, into glucose (dextro) and other bodies, which are mainly derivatives of benzene.

Tannin may be regarded as gallic anhydride.



Nitro-benzene, $\text{C}_6\text{H}_5\text{NO}_2$, is a volatile liquid, used in making cheap perfumery and flavoring essences.

When nitrobenzene is acted on by nascent hydrogen it is changed to *phenylamine*, $\text{C}_6\text{H}_5\text{NH}_2$, also known as amidobenzene, or *aniline*.

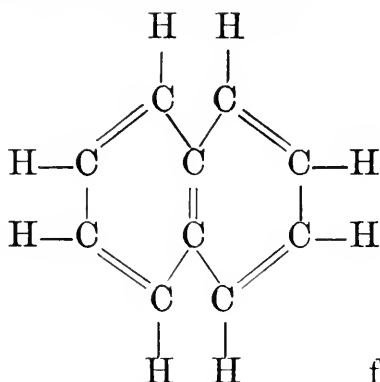


Aniline is a liquid, slightly heavier than water. It possesses a *smooth* disagreeable odor; is strongly basic and unites with acids to form salts. It is the basis of aniline dyes. And thus from the benzene of coal tar, erstwhile a waste product in the manufacture of illuminating gas, comes those splendid colors, which confer on fabrics of silk, etc., the elegant shadings now so noticeable.

Trinitrophenol, $\text{C}_6\text{H}_2 \begin{smallmatrix} (\text{NO}_2)_3 \\ \text{OH} \end{smallmatrix}$, is also known as picric acid. The picrates are highly explosive salts.

Many derivatives of benzene are used in medi-

cine, such as *salol*, a compound of salicylic acid and phenol; *phenacetine*, and the analogous compound, *acetanilide*, $C_6H_5-NH-C_2H_3O_2$; *resorcin*, $C_6H_4(OH)_2$; *pyridine*, C_6H_5N ; *naphthaline*, $C_{10}H_8 =$



formulated by

over lapping of two benzene rings; *quinicine*, $C_9H_9N_2$, to which antipyrine, $C_{11}H_{12}N_2O$, is related, etc.

They are antiseptic, antipyretic, and analgesic; and alone, or in various combinations with each other, or with other drugs, they are effective in performing the functions assigned.

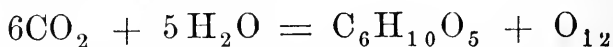
Their dosage ranges from 0.25 Gm. to 1.00 Gm. (gr. iv-xvi), and their probable action consists of destructive deoxidation of *protoplasm*.

CHAPTER XIII.

CARBO-HYDRATES.

Carbo-hydrates, so-called, because their molecules represent H and O in the proportion to form water, united to carbon. They include *starch*, *woody fiber*, and *sugars*.

STARCH, $C_6H_{10}O_5$, is an important constituent of the vegetable kingdom, especially in grains, such as corn, wheat, and rice, and in potatoes. It is probably formed in the plant, somewhat according to the following equation :



Starch consists physically of minute granules, insoluble in water, but which, when heated with water to 71° ($160^\circ F$), burst open and form *starch paste*. When heated to 205° ($400^\circ F$) starch is changed to isomeric *dextrin*, a soluble substance used on the *sticky* surface of postage stamps. The same isomeric change is produced on starch by certain dilute acids. Dilute sulphuric acid turns starch to dextrin, then to *glucose*. *Saliva* also produces a similar change, as does the ferment on the

farinaceous mixture in the first stages of alcoholic fermentation.

The natural *gums* contain polymers of starch. Gum-arabic is a combination of potassium and calcium, with arabic acid $(C_6H_{10}O_5)_2$. Agar-agar, or Ceylon moss, used for thickening soups and jellies, and in cultures for growing microbes; and other vegetables, as beets and carrots, as well as many fruits, contain polymers of starch and dextrin. Animal starch, *glycogen*, is found in the liver and placenta.

Solutions of starch and iodine, when mixed, turn to blue, by which the presence of starch, as distinguished from its isomers, may be determined.

CELLULOSE, $C_6H_{10}O_5$, is the chief constituent of vegetable fiber. Bleached cotton is practically pure cellulose, as is also linen that has been frequently laundried, a process which removes the inherent gums and resins from the surface.

When cellulose is treated with nitric and sulphuric acids, NITRO-CELLULOSE, or *guncotton*, also known as *pyroxylin*, $C_6H_7(NO_2)_3O_5$, is produced. Guncotton is highly explosive.

CELLULOID consists of pyroxylin mixed with camphor, zinc oxide, and coloring matters, and subjected to pressure while in the pulpy state.

Collodion is obtained by dissolving guncotton in a mixture of alcohol and ether. When the liquid collodion evaporates, it leaves a coherent film, known in surgery as a sort of artificial skin. *Cantharidal collodion*, is used with some advantage as a counter-irritant in periodontitis.

THE SUGARS are divided into two groups, *sucroses*, and *glucoses*.

SUCROSES have the formula, $C_{12}H_{22}O_{11}$, and include *cane* and *beet* sugar (sucrose), *milk* sugar (lactose), and a variety of *starch* sugar (maltose), etc.

GLUCOSES, $C_6H_{12}O_6$, include *grape* sugar (dextrose), and *fruit* sugar (levulose), etc.

Cane sugar (Sucrose), is obtained from the sugar cane, sugar beet, sorghum, and sugar maple. It is a most important article of human diet. When refined, cane sugar, presents a white crystalline form, perfectly soluble in water. When heated it loses part of its aqueous elements, and is converted into *caramel*.

Grape sugar (Glucose) exists in many sweet fruits, and in honey; it occurs also as a concomitant in the disease known as *diabetes*.

Glucose is largely produced artificially, by action of dilute sulphuric acid upon corn starch. It is

used extensively as a substitute for cane sugar, being cheaper, in the making of syrups, and candies ; and on account of its ability to ferment, in the production of beer and ale.

CHAPTER XIV.

TERPENES, ETC.

THE TERPENES, $C_{10}H_{16}$, are homologous with *pentone*, C_5H_6 , having the general formula C_nH_{2n-4} ; and are isologous with *decane*, $C_{10}H_{22}$. They exist in the volatile or essential oils of certain trees and plants, especially of the coniferous and aurantiaceous orders. They have not as yet been produced artificially, although some of them are structurally related to benzene.

Their formula is isomeric with *decane*, $C_{10}H_{22}$, and are regarded as tetrad radicals; although apparently satisfied, they are capable of taking up two molecules of HCl. If the molecule, $C_{10}H_{16}$, be doubled, the polymer, $C_{20}H_{32}$, as in the case of

2 atoms of carbon, $\begin{array}{c} | \quad | \\ -C-C- \\ | \quad | \end{array}$, loses 2 units of valency, and becomes a hexad.

Cologne is an alcoholic solution of certain essential oils.

Turpentine Oil, *Oleum Terebinthinæ*, $C_{10}H_{16}$, is the most familiar representative of the *terpenes*. It is obtained by distilling the juices which exude

from cuts in the bodies of several species of the genus *pine*. The commercial variety contains some admixture of other hydrocarbons, and traces of oxidation products.

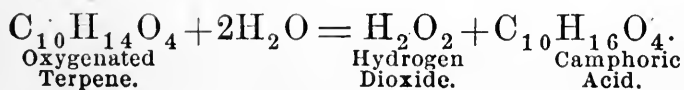
Rosin which remains in the retort, consists essentially of silvic acid, $C_{19}H_{29}COOH$.

Other resins, such as *shellac*, *copal*, *sandarac*, etc., are *rosins*, obtained similarly from various terpenes by distillation, or as the exudate from various kinds of trees.

The terpenes are disposed to absorb oxygen from the air, and thus pass into *camphors*.

That many volatile oils isomeric with oil of turpentine, such as oil of neroli, bergamot, cloves, pepper, caraway, lemon, etc., should exhibit such diversity of physical properties, is a problem which stereo-chemistry will doubtless be able to explain satisfactorily, in the near future.

The antiseptic, and disinfectant, properties of the terpenes (essential oils) are in all probability due to their power of taking up oxygen from the air, by which two atoms of hydrogen are removed, resulting in $C_{10}H_{14}O_4$, a highly oxidized hydrocarbon, which with moisture, and summer-heat, develops nascent oxygen.



MATERIA MEDICA.—Although many of the essential oils (especially that of cloves), have been, from time immemorial, favorite domestic remedies against *toothache*; and in practice, as ingredients of pulp *cappings*, their introduction as disinfectant, and antiseptic dressings, in root canals, is mainly due to Drs. Harlan, Black and Barrett.

OIL OF CLOVES, *oleum caryophylli*, is obtained by distilling the dried buds (cloves) of an evergreen tree of the myrtle order, *Eugenia caryophyllata*. The oil consists of *caryophyllin*, $C_{10}H_{16}$, and an oxygen oil, *eugenol*, or eugenic acid, $C_9H_{11}COOH$. When fresh it is colorless, but by exposure, becomes yellow, and finally, reddish-brown. It possesses a strong fragrant odor, and a hot aromatic taste; is nearly insoluble in water, but freely soluble in alcohol. When mixed in small proportion with either carbolic acid, or creasote, it effectually masks their peculiar odors. If applied to irritable dental pulp, in odontalgia, it reduces sensibility by its power of extra stimulation, and as a dressing in root canals, by its diffusion through the tubuli, and its ultimate reduction to a camphor, prevents a return of the process of putrefaction in the part and the consequent pathological sequelæ.

It is frequently exhibited internally as an anti-

spasmodic stimulant, in flatulent colic, nausea, and vomiting.

Dose, 0.12-0.30 fGm. (℥ ij-v)

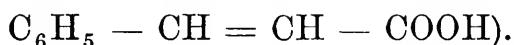
OIL OF SASSAFRAS is obtained by distilling the bark and wood of the root of the *sassafras officinalis*, a native tree, of the genus *laurel*. The oil has a pleasant odor, a warm pungent aromatic taste; oxidized by cold nitric acid, it is converted into a red resin. It is an excellent germicide, and is one of the ingredients of "sarsaparilla" syrup. The aqueous *infusion* of sassafras root bark is a popular "tea" and "blood purifier." Sassafras possesses mild astringent, stimulant alterative and diaphoretic properties. The powdered root, mixed with "chewing gum," and used as a masticatory, is a good adjunct in the treatment of alveolar pyorrhœa.

Dose of the oil, 0.06-0.25 fGm. (℥ j-iv)

OIL OF CINNAMON, *oleum cinnimomi*, is obtained from the inner bark of the shoots of the *cinnamomum zeylanicum* (cassia), trees of the natural order Lauraceæ, growing in China, Ceylon, and adjacent countries. The Ceylon variety is the most esteemed.

The oil is somewhat heavier than water; of an agreeable odor, and a very hot penetrating taste. It is a powerful local stimulant, and when applied

to an aching dental pulp, relieves the pain. It is also a diffusive disinfectant and antiseptic, and is employed as such, preparatory to filling root canals. On exposure, the oil of cassia tends to develop cinnamic acid (phenyl-acrylic acid,



The properties of cinnamon, as a sialogogue, stimulant, astringent carminative, and uterine hemostatic, when taken internally, is due to its contained oil and resin, and some tannic and cinnamic acids.

Dose of the oil, 0.06–0.30 fGm. (m g-v)

CHAPTER XV.

TERPENES, ETC.—(CONTINUED).

OIL OF WINTERGREEN, *oleum Gaultheria*, from the leaves of the indigenous evergreen plant, *Gaultheria procumbens*, or Partridge-berry; it exists also in the *sweet birch*, and other plants, and is largely composed of methyl salicylate $\text{CH}_3\text{C}_7\text{H}_5\text{O}_3$. It is the heaviest of the essential oils, and is largely used for flavoring; its principal use in dentistry is to disguise the disagreeable tastes and odors of other certain drugs, albeit it is itself an excellent antiseptic. It is employed internally in rheumatic disorders, as a pleasant substitute for salicylic acid. A cold "tea" of the leaves of the plant, is a popular astringent, carminative, and emmenagogue.

Dose of the oil 0.20–0.60 fGm. (℥ iij–x.)

OIL OF EUCALYPTUS, *oleum Eucalypti*, from the leaves of the matured *Eucalyptus Globulus*, or blue gum tree, a native of Australia, but now grown to some extent, in Italy, California, etc. The oil has a pleasant aromatic odor, a pungent somewhat cam-

phoraceous, cooling taste; it is composed of *terpene*, $C_{10}H_{16}$, *cymene*,



and *eucalyptol*, $C_{10}H_{15}(OH)$. It exhibits a destructive influence on microbic forms of animal and vegetable life.

Alone or combined with other antiseptics, it is effective in treatment of suppurating pulps, oral ulcerations, pyorrhœa, and chronic alveolar abscess. It is a solvent for gutta percha.

Internally administered, the preparations of eucalyptus, act as a stimulant to the brain and nervous system; they increase the circulation, and respiration, and are sialogogue, and diaphoretic; and tonic in gastric dyspepsia.

Dose of oil 0.30–2.00 fGm. (m_v–xxx.)

Dose of tincture 2.00–8.00 fGm. (f_{3ss}–ij.)

R. Olei eucalypti.

Acidi carbolici aa 6.00 fGm. (f_{3jss}.)

Olei Gaultheria 2.00 fGm. (f_{3ss}.)

M. S. Apply by syringe, in pyorrhœa (Dr. G. V. Black, from Gorgas.)

OIL OF CARAWAY, *oleum cari*, is obtained from the fruit of a European plant, the *Carum Carvi*. Its odor is aromatic, and its taste acrid. It consists of

the terpene, *carvene* $O_{10}H_{16}$, and the ten carbon phenol, *carvol*, $C_{10}H_{13}OH$.

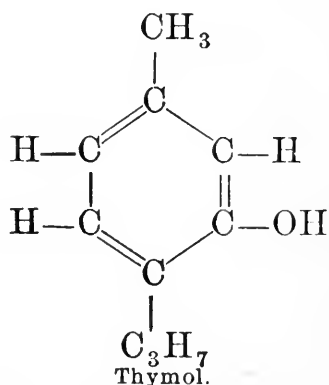
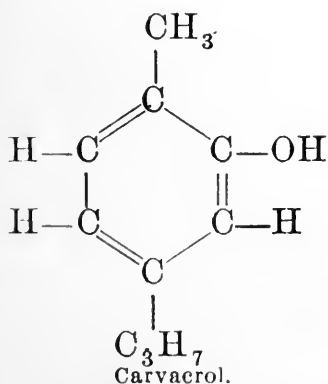
Dose of the oil 0.06-0.30 fGm. (m j-v.)

CARVACROL, $C_{10}H_{13}OH$, is isomeric, and probably identical with carvol. It has a taste, persistent and strongly acrid, and a creasotic odor. It is a solvent for gutta percha. Is disinfectant and anti-septic; and is analgesic, and escharotic on sensitive dentine.

Its principal source is oil of caraway.

Dose, not used internally.

THYMOL, $C_{10}H_{13}(OH)$, is isomeric with carvacrol. It is a constituent of the volatile oil of the garden plant, *Thymus vulgaris*, and of several other plants. The isomeric relation of thymol, to carvacrol, may be most easily understood by the benzene *hat-rack*,



Both are *methyl-propyl-phenols*. In carvacrol the

methyl group (CH_3) stands to the hydroxyl group (OH) in the *ortho*-position, and in thymol, in the *meta*-position.

Thymol crystallizes in transparent plates, of a mild pleasant odor, and peppery taste. It is practically insoluble in water, but is freely soluble in alcohol, chloroform, and ether, and liquefies with camphor, and chloral alkalies. It forms, with glycerine, a good antiseptic.

ARISTOL, $\text{C}_{10}\text{H}_{13}(\text{OI})$, is obtained from an alkaline solution of thymol, by adding potassium iodide solution of iodine, by which is produced a red-brown amorphous precipitate, consisting of thymol, minus its hydroxyllic H, plus I, and may be chemically known as *thymol iodroxide*.

Aristol occurs in impalpable powder, almost tasteless and odorless. It is insoluble in water, glycerine, alcohol, and alkalies, but freely soluble in chloroform and ether, and is readily decomposed by light and heat.

Its insolubility in water enables it to act as an antiseptic, by preventing egress to the part, of septic germs; and as a germicide, by the free iodine, which it slowly gives off, at the temperature of the mouth.

Cotton wool, holding a saturated solution of

aristol in chloroform, or ether, placed between teeth or over dressings in their cavities, will remain comparatively odorless for indefinite periods of time.

Dose—Not used internally.

CHAPTER XVI.

TERPENES, PHENOLS, ETC.—(CONTINUED.)

RESORCIN, $C_6H_4(OH)_2$, as may be presumed from its formula, is closely related to carbolic acid. It is a diatomic phenol, obtained by fusing caustic alkalies with certain gums, as galbanum, or with potassium-benzol-disulphonate. By the latter process resorcin and potassium sulphite result.

Rosorcin occurs in prismatic shining crystals, of a sweetish pungent taste, freely soluble in water, less so in alcohol, ether, and glycerine, and not at all in chloroform. It is not so caustic and irritating as carbolic acid, although in strong solution it is fully as good an antiseptic. It is preferred to carbolic acid as an internal antiseptic and antipyretic, being less poisonous.

Dose, 0.30 Gm. (gr. v)

OIL OF PEPPERMINT, *oleum menthæ piperitæ*, obtained by distilling the fresh leaves of the plant. It consists of a terpene and a monatomic alcohol, the latter called *menthol*, $C_{10}H_{19}(OH)$; also known as peppermint camphor.

MENTHOL, applied locally, is a non-corrosive vascular stimulant, antiseptic, and anæsthetic.

PYRETHRUM, *Pellitory*; the root furnishes an oil which, applied in ethereal solution, relieves adontalgia. The flowers of Persian pellitory are used as "insect powder."

OIL OF ORANGE FLOWERS, *oleum neroli*, is of delightfully fragrant odor.

CAOUTCHOUC, India-rubber, is a thickened *gum* of the milky juice of several trees, as *Euphorbia*, growing in tropical countries. Para gum, shipped from Para, on the Amazon, is the most highly prized. Caoutchouc consists essentially of a mixture of terpenes, isomeric or polymeric, with oil of turpentine ($C_{10}H_{16}$). It softens by heat; is not soluble in water or alcohol, but dissolves in chloroform, pure ether, turpentine, benzene, and carbon disulphide. Mixed in variable proportions with sulphur, and heated, it becomes *vulcanized India rubber*. With one-half its weight of sulphur, *ebonite* is formed. Coloring matters are also often added, as vermilion (Hg_2S), to give it a red color; white clay and zinc oxide, to produce white rubber, etc.

GUTTA-PERCHA is the hardened juice of the *isonandra percha* tree, growing in Malacca and adjacent islands. It resembles caoutchouc in many respects, being insoluble in water, and capable of

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vulcanizing with sulphur. It is less elastic than rubber, and is a very poor conductor of electricity, hence it is extensively used as an electric *insulator*. Gutta-percha, mixed with zinc oxide, is used as a "filling" material, and retains its identity in the teeth against chemical action, but soon succumbs to active attrition.

NAPHTHALINE, $C_{10}H_8$, is a product of the distillation of coal-tar. It occurs in large white crystals of tarry odor and somewhat aromatic taste; insoluble in water and in dilute acid and alkaline solutions, but soluble in chloroform, ether, volatile and fixed oils, benzene, and hot alcohol. It is a valuable antiseptic; combined with iodoform it forms an excellent dressing in root canals.

HYDRONAPHTHOL, $C_{10}H_7OH$, derived from naphthaline, crystallizes in shiny white scales, sparingly soluble in water, freely soluble in alcohol, glycerine, etc. It is non-poisonous, but is an excellent germicide and antiseptic in dental practice, and is also favorably exhibited as such, in general practice, especially in ailments of the intestinal canal.



CHAPTER XVII.

RESINS, CAMPHORS, ETC.

MYRRH is a fair representative of *gum resins*. It is an exudate from the stems of the *Balsomodendron myrrha*, a small tree of South-western Asia and Northern Africa. When comparatively pure, it comes to us in semi-transparent yellow-reddish tears, held together in considerable bulk, of agreeable odor and aromatic bitter taste. It may be pulverized, and is soluble in ether and alcohol. It is a mild stimulant astringent to mucous surfaces, and is an effective application in the form of powder or tincture, to relaxed ulcerated conditions of the gums and throat.

Dose of the tincture, 2.00–4.00 fGm. (f3ss–i)

R. Aluminis, 4.00 Gm. (3i)

Tincture Myrrhæ, . . . 8.00 fGm. (f3ij)

Infusi Rosæ comp. . . 160.00 fGm. (f3v)

M. S. Use as a gargle.

(Modified from Farquharson.)

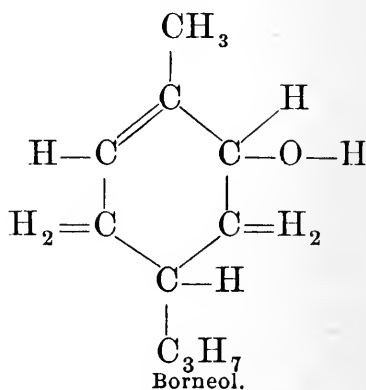
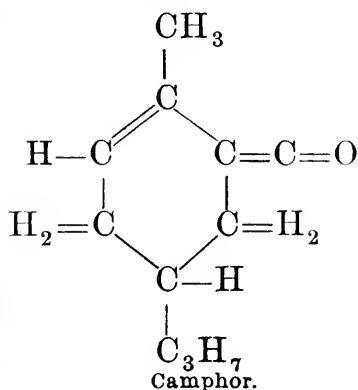
CAMPBOR, $C_{10}H_{16}O$, *common camphor*, (like other camphors, such as caryophyllin, $C_{20}H_{32}O_2$), may be regarded as an oxygenated terpene. Closely re-

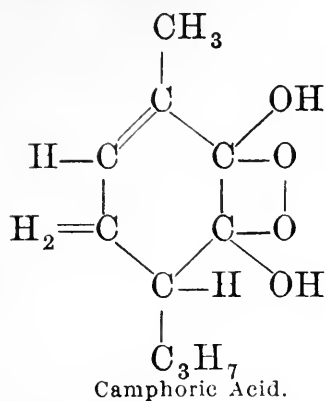
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lated to these, are many solid and liquid camphors which react as alcohols or stearoptenes, such as *Borneol*, or Borneo camphor, $C_{10}H_{17}OH$, and its homologue, *patchouli camphor*, $C_{15}H_{27}OH$, *menthol*, or mint camphor, $C_{10}H_{19}OH$, *absinthol*, $C_{10}H_{15}OH$, etc. Camphors are also obtained from the volatile oils of many plants, such as the oils of lavender, cajeput, orange, rosemary, coriander, hops, marjoram, etc., etc. By reaction with strong oxidizing agencies, such as nitric acid, ozone, etc., they are changed into acid compounds, of which *camphoric acid*, $C_8H_{14}(COOH)_2$, is a fair representative.

The chemical relation between camphor, which is a *ketone*, and Borneol, which is a monatomic *alcohol*, and camphoric acid, may be differentiated by erecting them in graphic formulæ, thus:





Common camphor is obtained in a crude way by distilling with water the wood of the *Laurus camphora* tree of South-eastern Asia. It is a colorless translucent solid, of sp. gr. 0.935; of a penetrating, aromatic odor, and rather unpleasant taste; sparingly soluble in water, but freely soluble in volatile oils, strong acetic acid, ether and alcohol. Pieces of camphor thrown on water, show the high volatility of the substance by the vapor pressure on the water, causing a rotatory motion of the granules; if they be covered with oil, which prevents evaporation of the camphor, rotation in water will not occur.

Camphor is an important ingredient of many liniments in common use. When locally applied, it exhibits irritant, rubefacient, and finally, anodyne properties. Combined with chloral, or in strong solution with chloroform, it is an effective local anæsthetic, and is used as such in obtunding

sensitive dentine, exposed dental *nerve*, and in allaying the pain which often follows the extraction of teeth.

Internally administered, camphor is strongly antispasmodic, diaphoretic and anaphrodisiac. In large dose it is narcotic and depressant, but in small doses it is mildly stimulant and diaphoretic.

Dose, 0.06–0.60 Gm. (grj–x)

Chloral camphor is a liquid obtained by triturating together equal weights of chloral hydrate and camphor. The mixture exhibits antiseptic and obdusting properties, and is a good solvent for many alkaloids.

Campho-phenic, as its name implies, is a combination of camphor and carbolic acid. It is non-caustic and non-irritant, and is antiseptic and somewhat anæsthetic when applied to sensitive inflamed surfaces.

R. Camphora—

Chloral hydratis, aa, 16.00 Gm. (ʒiv)

Etheris sulph. 30.00 fGm. (fʒi)

M. S. For office use.

CAPSICUM, *cayenne pepper*, is the fruit of the plant *capsicum fastigiatum*. It possesses a peculiar odor and very hot taste, and contains *capsicin*, the active principle and a volatile alkaloid.

Capsicum is one of the most familiar of *local irritants*. They produce on the part, a vascular excitement which oftentimes modifies the pain of coming inflammation. Hence capsicum, as well as the fruit of the *piper nigrum* (black pepper), etc., are severally, and combined, employed in *plaster* form to prevent the painful development of expectant periodontitis, subsequent to the operation of filling root canals.

HUMULUS, *Hops*, the fruit cones, (strobiles,) of the common *hop-vine*, (*humulus lupulus*). The glandular portion of the strobiles consist of irregularly rounded small grains, of a yellow color, known as *lupulin*, which contains also, in most abundance, waxy resins and tannin, and a volatile oil, consisting of trimethylamine (valerol, and lupulinic acid.

Hops are mildly hypnotic, tonic, and somewhat astringent. They increase cutaneous circulation, when externally applied, followed by a soothing influence on sensory nerves. A calming effect is produced on localized inflammation, such as acute alveolar abscess, by a warm hop *poultice*, external to the part.

Dose of Lupulin, 0.30–0.90 Gm. (gr. v–xv.)

CALENDULA, the fresh flowering *garden marigold*, furnishes a *tincture* which possesses a stimulant

resolvent power, and which when applied to exposed pulp, or in alveolar sockets, after extraction of teeth, impresses itself favorably, by relieving in a large measure, the consequent pain.

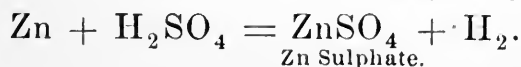
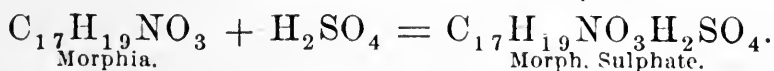
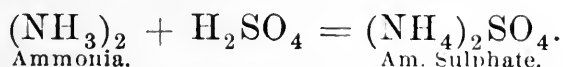
CHAPTER XVIII.

NATURAL ALKALOIDS.

ALKALOIDS are organic bases capable of uniting with acids to form salts. Many of them exist in union with characteristic acids, in certain vegetable products; they also occur in animal bodies, as *leucomaines*; and as a result of putrefaction, as *ptomaines*. They are mostly poisons, are closely related to the artificial *amines*, and contain N as an essential element.

Those that are made up of C, H, and N, as nicotine, $C_{10}H_{14}N_2$, etc., are generally volatile liquids; while those which also contain O, as Caffèine, $C_8H_{10}N_4O_2$, Morphine, $C_{17}H_{19}NO_3$, etc., are non-volatile solids.

Their *graphic* formulas are not as yet determined. When uniting with acids to form salts, they behave like ammonia; the hydrogen of the acid is not set free, thus differing in interaction with acids, from the general effect produced by metals.



Their names terminate in either *ine* or *ia* according to preference. As a rule, they are less soluble in water, than are their salts.

QUININE, *quinia*, $C_{20}H_{24}N_2O_2, 3H_2O$, is the most highly prized active principle of *Cinchona* bark.

The genus *cinchona* comprise many species. They were named in honor of the Countess of Cinchon who was cured of a relapsing fever by infusions of the bark, sent her by the Jesuit Missionaries in Peru.

Cinchona trees flourish mainly on the eastern slope of the Andes, between the 20th degree S. latitude, and the 10th degree N. latitude. They are now profitably cultivated in India, and in southern Asiatic islands.

Three varieties of *cinchona* bark are sufficient representatives of the entire genus.

1. C. CALISAYA, *C. Flava*, yellow bark.
2. C. SUCCIRUBA, red bark.
3. C. PALLIDA, pale bark.

Different *cinchona* barks contain variable quantities of numerous active medicinal alkaloids, of which *quinia* and *cinchona* are the most valuable. They exist in the bark, in union with *kinic* or *quinic*, (monobasic pentatomic) acid, $C_6H_7(OH)_4COOH$.

Quinine is separated from the bark, and the kinic acid, by dilute hydrochloric acid, which forms the

soluble quinia hydrochloride. By the addition of lime, calcium chloride is formed, taking thus from the quinia, the hydrochloric acid, and compelling the alkaloid to precipitate. This precipitate is washed in water, and taken up by boiling alcohol, which is afterward set free by distillation.

Quinine occurs as a white amorphous crystalline powder, inodorous, but of an exceedingly bitter taste; very sparingly soluble in water; freely soluble in hot alcohol, chloroform, ether, and the fixed and essential oils; is alkaline in reaction and forms salts with acids, of which the *sulphate* is the most generally employed, and which has appropriated the name, *quinine*.

Quinia sulphate, $(C_{20}H_{24}N_2O_2)_2, H_2SO_4, 3H_2O$, *quinine*, is rarely used locally.

In small doses, internally administered, it acts as a tonic, an antiseptic, and antiperiodic. In full doses it causes anemia of the brain, accompanied by ringing in the ears (cinchonism), partial deafness and blindness, and frontal headache.

It reduces the reflex irritability of the spinal chord. At first it increases, and afterward slows the heart's action. It increases the number of white corpuscles, but prevents their *amœboid* movements, and prevents, also, the due giving up of O to the tissues. For this latter influence, quinine

might be suggested internally in localized inflammation, such as acute alveolar abscess. It has but slight effect on the temperature of the body in full health; but in *fevers*, the temperature is diminished by quinine.

Dose, 0.12–1.25 Gm. (grij-xx)

R Quinia sulphatis, 1.00 Gm. (grxv)

Ft. capsules, No. 5.

S. Take one every two (2) hours.

(In either acute alveolar abscess or periodic supra-orbital neuralgia.)

Artificial substitutes for quinine are being rapidly introduced by manufacturers. They are generally of coal-tar origin, and belong to the benzene series, either directly, or as substitution products. Some of them have been alluded to on page 316. They also possess active analgesic, germicidal and antiseptic properties. Of these compounds, PYOKTANINE, *methyl violet*, is the one most used in dentistry, as an antiseptic dressing in root canals, but is objectionable as such, on account of its coloring influence on dentine. It is a violet blue powder, odorless, non-poisonous, sparingly soluble in water and alcohol, insoluble in ether, and very *diffusible* in animal fluids.

CHAPTER XIX.

ALKALOIDS—(CONTINUED).

MORPHINE, *Morphia*, $C_{17}H_{19}NO_3$, is the principal individual of the many active alkaloids found in opium.

OPIUM is the inspissated juice of the unripe capsules of the *papaver somniferum*, or white (or black) poppy, indigenous to Asia Minor, and cultivated extensively in other countries. The poppy is an annual plant, growing from 2 to 3 feet high. The milky juice obtained from incisions in the capsules (poppy heads), becomes concrete by exposure to the air, and comes to us, in irregularly rounded or flattened cakes, of a brown color, strong narcotic odor, and bitter taste, exciting to salivation. It yields its numerous virtues to water, and alcohol, and dilute acids, but not to ether.

Morphine exists in opium in union with meconic acid, $C_6H_3O_5COOH$. The favorite salt of morphine, is the *sulphate*, $(C_{17}H_{19}NO_3)_2, H_2SO_4 \cdot 5H_2O$, soluble in water and alcohol, but not in chloroform or ether. Consists of white flocculent crystals, of bitter taste; is less astringent and diaphoretic than opium, but possesses greater power as a hypnotic

and anodyne. Morphine is not regarded with much favor as a local anodyne; but if it be injected in solution hypodermatically, or taken by way of the *primæ viæ*, it exhibits the most distinguished narcotic properties. At first, the brain is gently excited, as with opium, followed by a soothing sedative effect; and sleep ensues, induced by cerebral anemia. Awakening is accompanied by headache, digestive disturbance, and (with opium) constipation.

Subcutaneous injection of, .

Morphia 0.01 Gm. (gr. $\frac{1}{6}$.)

Aqua Dest. 1.00 fGm. (℥ xv) M.,

will relieve the exceeding pain of periodontitis.

Coffee and Belladonna, or their most active alkaloids, *caffeine* and *atropine*, are the principal physiological *antidotes* to morphine.

Dose of Morphine, 0.01–0.02 Gm. (gr. $\frac{1}{6}$ – $\frac{1}{3}$.)

Dose of Opium, 0.06 Gm. (gr. j.)

Dose of Tinctura opii, 1.00 fGm. (℥ xv.)

Dose of Tinctura opii et camphorata, 4.00 fGm. (fʒi.)

COCAINE, is obtained from the leaves of *Erythroxylon Coca*, a small plant, indigenous to the mountainous portions of Peru and Bolivia, and now extensively cultivated elsewhere. The leaves have been used from time immemorial as a masticatory, by the natives of those countries, by aid of which, they are enabled to undergo fatiguing labor, with

apparent impunity, through the obtunding influence on the sensory nerves, and loss of the sensations of hunger, and thirst, produced by the drug.

Cocaine is a univalent base of alkaline reaction, and has the empirical formula, $C_{17}H_{21}NO_4$. It forms with acids, neutral salts, of which the *Hydrochloride* (vide "nomenclature" in Part first) is the most useful.

The distinction which cocaine hydrochloride has assumed as a local anæsthetic is well deserved. Applied to the mucous membrane, or ocular conjunctiva, or injected hypodermatically (hypodermically) in other parts, it causes profound anæsthesia over a limited area, sufficient for minor surgical operations. It causes thus, local anemia, by which probably the sensory nerves, are rendered unable to transmit normal impressions.

COCAINE HYDROCHLORIDE, $C_{17}H_{19}NO_4$, HCl_2H_2O , occurs as colorless small prismatic crystals, soluble in alcohol, water, chloroform, and vaseline, but not in ether. It is odorless, but possesses a bitter taste, followed by loss of the sense of taste, through its paralyzing influence on the peripheral extremities of the gustatory nerve.

0.65 fGm. (m_x) of the 5 per cent. aqueous solution injected into the immediate neighborhood of the apex of root, will develop sufficient local

anæsthesia to permit the painless extraction of the tooth. One of the best stimulants in *collapse*, which some times supervenes after the operation, is Hoffman's Anodyne (Spiritus Ætheris) in half teaspoonful doses, and also if necessary, subcutaneous injection of Atropine.

Aqueous solution of cocaine hydrochloride should be fresh, as it tends to rapidly deteriorate by fermentation; to overcome this latter difficulty, small proportions of salicylic acid, or carbolic acid, are added; and also as physiological antidotes, either atropine, or chloroform.

Various combinations of cocaine with other drugs, have been patented as local anæsthetics, and given suggestive names, by which confiding members of the profession are being extensively imposed upon. Practitioners, worthy of the name, should be possessed of more self respect than is indicated by the encouragement many of them extend to the mercenary aspect of such secret nostrums.

Cocaine is a cerebral stimulant; it also excites the general nervous system, and increases cardiac, and respiratory movement. In small doses it is a tonic and diuretic. In *Lethal* doses, death occurs by simultaneous cardiac and respiratory failure.

Dose—0.01 – 0.06 Gm. (gr. $\frac{1}{8}$ –j).

- R. Cocaina Hydrochloris 1.00 Gm. (gr. xv).
Atropia Sulphas 0.01 Gm. (gr. $\frac{1}{6}$).
Acidi Carbolici (cryst.) 0.25 Gm. (gr. iv).
Chloral Hydratis 0.20 Gm. (gr. iij).
Aqua Dest. Ad. 32.00 fGm. (f \bar{z} i).
- M. For extraction of tooth, inject 1.00 fGm. (m xv).
(Modified from formula given in "Transactions of Kansas D. A.")
- R. Cocaina phenatis 0.10 Gm. (gr. jss).
Alcoholis (ad solve) 4.00 fGm. (f \bar{z} i).
Aqua Dest. 6.00 fGm. (f \bar{z} jss).
- M. Six (6) Injections.
- R. Cocaina Hydrochloris (cryst). Insert in moist cavity, and let remain ten minutes; for sensitive dentine.
- R. Cocaina Hydrochloris 0.10 Gm. (gr. jss).
Alcoholis, Chloroformi aa 4.00 fGm. (f \bar{z} i).
- M. Apply to Gum as a local anæsthetic (Dr. H. J. McKellop, from Gorgas).

CHAPTER XX.

ALKALOIDS, ETC.

ACONITINE, $C_{33}H_{43}NO_{12}$, is the active alkaloid of the leaves and root of the *Anconitum Napellus*, or *monkshood*, a perennial plant, indigenous to the mountainous portions of Europe. The leaves are deeply divided; the flowers of a purple blue color, and of bell-shaped pendant form. All parts of the plant possess medicinal bitter properties, but the root is richest in active principles. *Tinctura aconiti radidis* is the most favored preparation.

Tincture of aconite, applied locally, causes a tingling, burning sensation, followed by numbness, due probably, to the paralyzing influence of aconite on the extremities of the sensory nerves. It produces sedative and anodyne effects when used topically in neuralgia and rheumatism, and relieves the pain of acute periodontitis.

When taken internally, even in full doses, aconite does not interfere with the normal intellectual faculties of the brain. The reflex irritability of the spinal chord is greatly diminished, cardiac action, respiratory movement, and temperature are

reduced. It increases the flow of saliva and the secretions of the skin and kidneys.

On account of excessive slowing of the heart's action by aconite, its employment should be avoided in cases of suspected cardiac weakness.

Antidotes: Emetic, animal charcoal *pulv.* Tannin, hot alcoholic stimulants, and digitalis; also, amyl nitrite.

Dose, tincture of the root, 0.06–0.30 fGm. (m̄j–v)

“ Aconitine, . . . 0.001 Gm. (gr. $\frac{1}{64}$)

ATROPINE, $C_{17}H_{23}NO_3$, is the active medicinal principle of the root and leaves of *atropa belladonna*, or *deadly nightshade*, a perennial herbaceous plant, natural to the mountainous regions of Southern Europe and Asia, but now cultivated in this country and elsewhere.

Atropine Sulphate $(C_{17}H_{23}NO_3)_2H_2SO_4$, is much more soluble in water than is the alkaloid. It is also freely soluble in alcohol, but not in ether. It is neutral in reaction, without odor, and of a bitter taste, and like aconitine, very poisonous.

Topical application of belladonna preparations is soothing and anodyne in neuralgic pains and in abscesses, and is efficacious in reducing or arresting suppurative processes, localized perspiration and the secretion of the mammary glands. Taken internally, belladonna causes gentle hallucinations of a joyful character, and calming sleep. The reflex

irritability of the spinal chord is diminished, but cardiac and respiratory movements are increased.

These latter phenomena are supposed to be due to paralysis of the pneumogastric nerve; which condition permits the sympathetic nerves to come into full play, ungoverned for the time being, by the pneumogastric, and thus exert their peculiar power. Belladonna therefore is a temporary cardiac tonic.

It induces dilatation of the pupil, by its paralyzing influence on the motor-oculi nerve, which supplies the sphincter muscular filaments of the iris, allowing the sympathetic, which rules over the radiating fibers, to become extra-active in the performance of its usual function. Belladonna, checks the secretion of saliva, by selective influence on the secretory branches of the chorda tympani nerve, supplied to the submaxillary ganglion.

Antidote: Animal charcoal, vegetable astringents, opium, calabar bean (*physostigma venenosum*), and tartar emetic.

Dose, Atropine 0.001 Gm. (gr. $\frac{1}{84}$.)

Dose, Fluid Extract of root 0.06–0.30 fGm. (m.j.–v.)

R. Extractum Bellad. fluidum Rad.

Tinctura Aconiti Radicis aa 8.00 fGm. (3ij.)

Acidi Carbolicum 0.30 fGm. (gttv.)

Chloroformi 30.00 fGm. (f3i.)

M. S. Poison. Use as a liniment only, in painful restricted inflammation.

HYOSCYAMINE, the principal alkaloid from the leaves of *Hyoscyamus Niger* (Henbane) a biennial plant, and DATURINE from the leaves and seed of *Datura Stramonium*, are chemically identical with Atropine, and possesses like the latter anodyne and antispasmodic properties.

The *Datura Stramonium* plant, also known as Thornapple and Jimson (Jamestown) weed, is an annual of common occurrence.

A poultice of *Jimson* leaves, is very efficacious in reducing the pain and swelling, in acute alveolar abscess.

CANNABIN, is the most active principle of *cannabis sativa* or *Hemp*, (*Cannabis Indica* and *C. Americana*).

Cannabis sativa must not be confounded with *Apocynum Cannabinum* "Canadian, or Indian Hemp," the common *Milkweed*.

Cannabis sativa furnishes several preparations of more or less mystical importance.

Gunjah is the dried female flowers and leaves, sold for smoking purposes. *Churrus* is a resinous substance obtained by rubbing together the leaves of the plant; and *Hasheesh*, or *bhong*, consists of the small broken stalks and leaves, mixed with aromatics and fruits.

Preparations of *Cannabis Sativa* taken in full dose, cause an exalted intoxication, and loss of

conception of time, followed by sleep, and great depression; they act in moderate doses, as antispasmodics, and aphrodisiacs.

Applications of warm *Tinctura Cannabis Indica*. (Dose, 2.00–4.00 fGm. (m xxx–lx) has been suggested as a local anæsthetic, in the operation of extracting teeth.

HAMAMELIS VIRGINICA, or *Witch Hazel*, is a native shrub, from the bark and leaves off which, a *fluid extract* is obtained, possessed of tonic, astringent, and anodyne properties.

Dose of the Fluid Extract 0.06–4.00 fGm. (m j–lx.)

R. Extractum Hamamelidis Fluidum 4.00 fGm. (fzj.)

Aqua Dest. q. s. Ad. 30.00 fGm. (fzj.)

M. S. An excellent lotion to sore gums, after removing salivary calculus.

Numbers of new remedies belonging mainly to the “Antiseptic” class, have been introduced during the present year.

They are generally termed by their manufacturers, “Synthetic” (better, *Artificial*), preparations, to distinguish them from natural products. Their names are some times quite fanciful; two at least, of which are ridiculously similar in sound and orthography, *i. e.*, *Europhen* and *Euphorin*. The first is probably named in honor of Europe, and the other in recognition of the genus *Euphorbia* tree,

from one of the species of which, our *Rubber* is obtained.

EUROPHEN occurs as a yellow tasteless, odorous powder, insoluble in water, and glycerine, but soluble in ether, alcohol, and chloroform.

Locally, it is anæsthetic, and antiseptic, and presumes to act as a substitute for Iodoform, being less poisonous, and decidedly of less unpleasant odor. It is prepared by dehydrating Isobutyl alcohol and ortho-cresol, by zinc chloride, resulting in *isobutyl-orthocresol*, which, dissolved in alkali, and acted upon by solution of iodine in potassium iodide, precipitates as Europhen. It consists of hydro-carbon radicals, about 72 per cent. and of iodine 28 per cent, while iodoform is made up of hydro-carbon, 3 per cent and of iodine, 97 per cent.

Europhen is, therefore, comparatively very weak in iodine, which fact, however, need not prevent the manifestation of the virtues ascribed to it, inasmuch as the action of any drug, local or general, does not necessarily depend on its chemical decomposition.

EUPHORIN is a crystalline, substance structurally related to carbolic acid, and acetanilide, and is therefore easily erected on the benzene ring. It is insoluble in water, but dissolves in alcohol, and is recommended internally, as an effective anti-pyretic, and analgesic.

ASAPROL is a crystalline substance, and DIAPH-
THERIN, is an amorphous powder. Both are soluble
in water, and possess active germicidal, and anti-
septic properties.

Analysis of Teeth (Berzelius):

Organic substance	28.0
Calcium phosphate	64.4
Calcium carbonate	5.3
Magnesium phosphate	1.0
Sodium carbonate and chloride	1.3
	<hr/> 100.0

(FREMY).

	Ash.	Calcium Phos.	Mag. Phos.	Cal. Carb.
Enamel,	96.9	90.5	traces.	2.2
Dentine,	76.8	70.3	4.3	2.2
Cement,	67.1	60.7	1.2	2.9

[*Taken from Mitchell's Chemistry.*]

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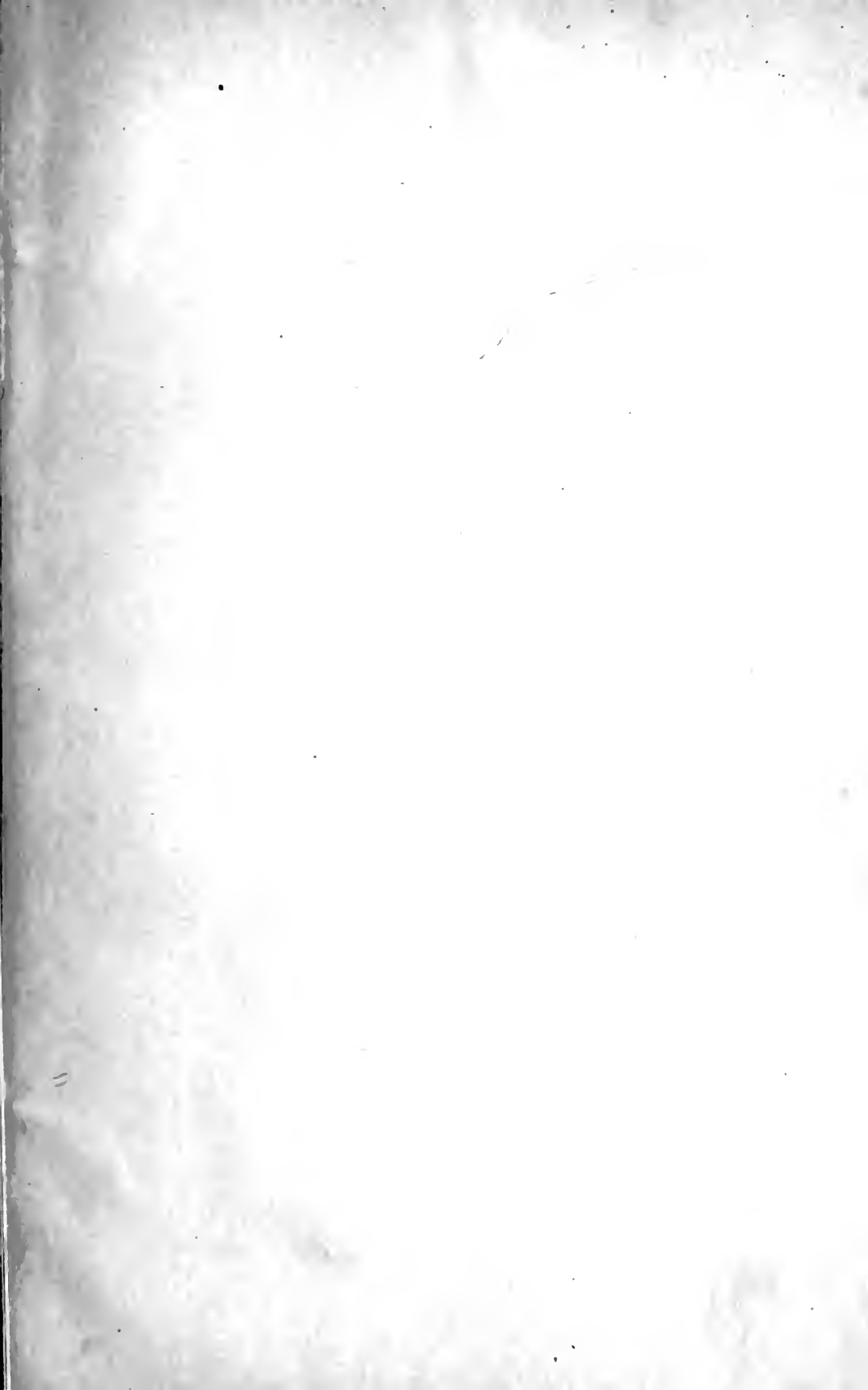
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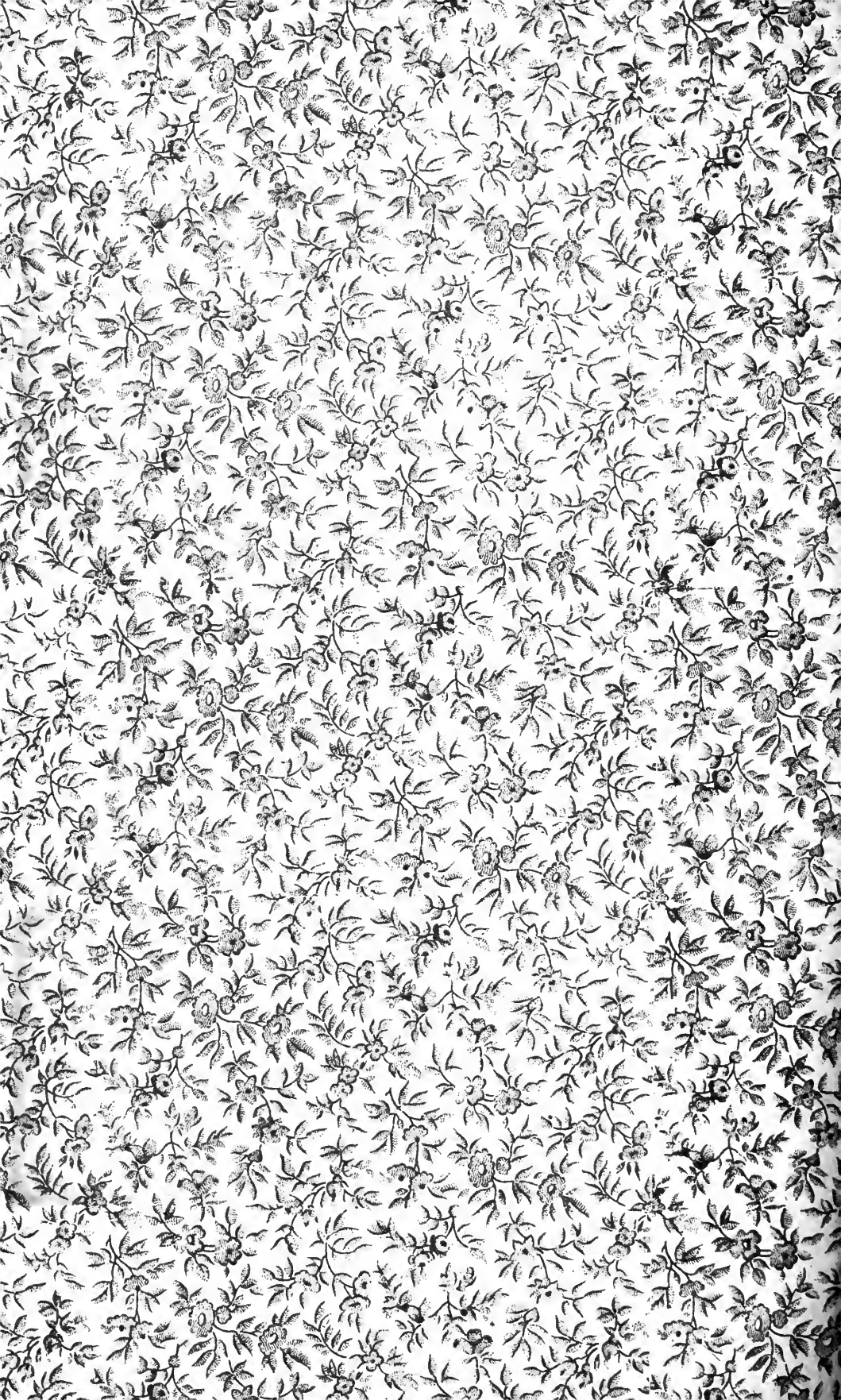
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